STRATEGIC TARGET SYSTEM (STARS)

STARS I HANDBOOK FOR PAYLOAD DESIGNERS

SM-PH-01
REVISION A

APRIL 1994

Originator: Margaret R. Weber **Date: April 5, 1994**

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1. ABSTRACT

This document identifies mandatory design, development and integration requirements for payload reentry vehicle (RV) experiments and support equipment (SE) which must be complied with by payload designers to utilize the Strategic Target System (STARS) I launch system. Reference information on the STARS I system capabilities and limitations are provided to aid payload designers in using the STARS I to support specific payload mission objectives.

The *STARS I Handbook for Payload Designers* identifies Kauai Test Facility (KTF) as the launch facility, supported by the Pacific Missile Range Facility (PMRF), and the Kwajalein Missile Range (KMR) as one possible impact area, using an approximate 2000 nautical mile ballistic trajectory. Other specific targets are within the overall capability of the STARS I system. These capabilities will be identified to potential payload designers as required on an individual basis.

NOTE: Questions arising from this document should be addressed to Sandia National Laboratories Large Rocket Systems Department 9825 through the Strategic Targets Product Office at USASSDC.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

Page

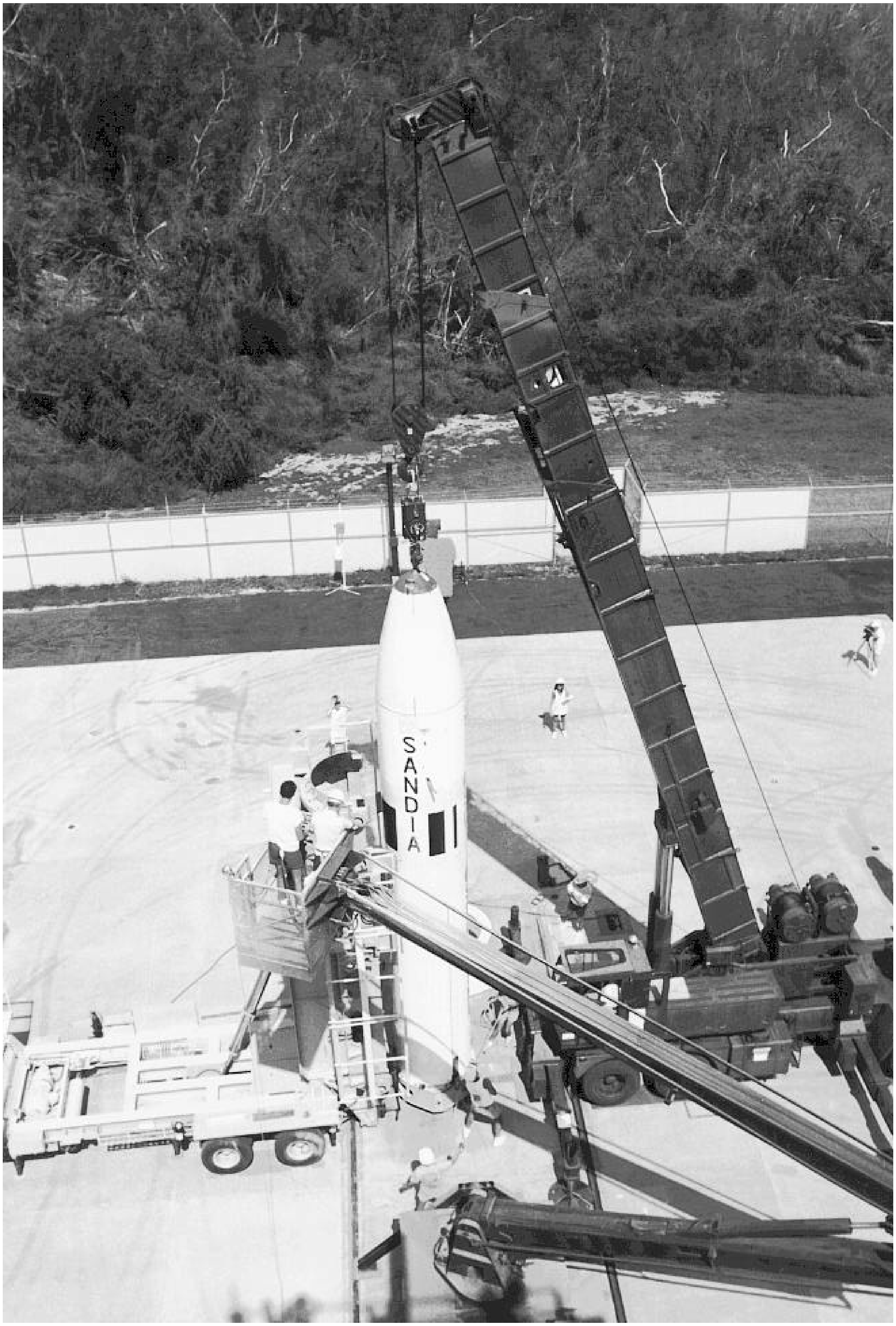
LIST OF FIGURES

LIST OF TABLES

Page

LIST OF TABLES

Page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1. INTRODUCTION

The design of the STARS rocket system began in early 1986[1]. The STARS system has shown that it is capable of meeting its design objectives. This document is designed to assist payload designers in planning for their R&D flight test experiments, establishing the interface requirements, generating the representative flight profiles, and defining the flight environments. The payload pertains to all items contained within the volume defined by the inside profile of the nose shroud and the payload mounting surface. This volume includes the payload's associated mounting and ejection hardware, third stage retro motors, and all payload electrical connectors and cables forward of the payload mounting plate.

1.1 BACKGROUND

The Strategic Target System (STARS) I is a three-stage booster designed to launch Research and Development (R&D) payloads from the Department of Energy (DOE)/Sandia National Laboratories (SNL) Kauai Test Facility (KTF), located on the Pacific Missile Range Facility (PMRF) in the State of Hawaii, to the Kwajalein Missile Range (KMR) at the US Army Kwajalein Atoll (USAKA). The STARS program is managed by the US Army Space and Strategic Defense Command (USASSDC) Strategic Targets Product Office (USASSDC/CSSD-TE-S) as the executing agent for the Ballistic Missile Defense Organization (BMDO).

A typical flight profile for a STARS I reentry experiment mission is shown in Figure 1.1-1. Other flight profiles, such as a carrier system for heavier payloads, are within the overall performance capabilities of the STARS I booster system. These flight profiles are defined in more detail in Section 2.2. These capabilities can be explored with potential payload designers on an individual basis.

Initial requests for mission support should be made to the Strategic Targets Product Office. USASSDC/CSSD-TE-S, SNL and the payload designers will conduct preliminary planning for the mission. Once the preliminary planning is accomplished, detailed planning will be coordinated with the Large Rocket Systems Department 9825 at SNL. In addition to detailed planning for the mission, the payload designers must work with USASSDC to develop range requirements documents under the Universal Documentation System (UDS) to obtain the needed range support through the lead range, PMRF.

A variant of the STARS I is under development, with the first mission scheduled to occur in 1994. Payloader's information for this vehicle, the STARS II, will be covered in a separate handbook.

[1] Watts, A. C., et. al., *Strategic Target System (STARS) Launch Vehicle*, paper presented at the AIAA Missile Science Conference, Monterey, CA, Nov. 1988.

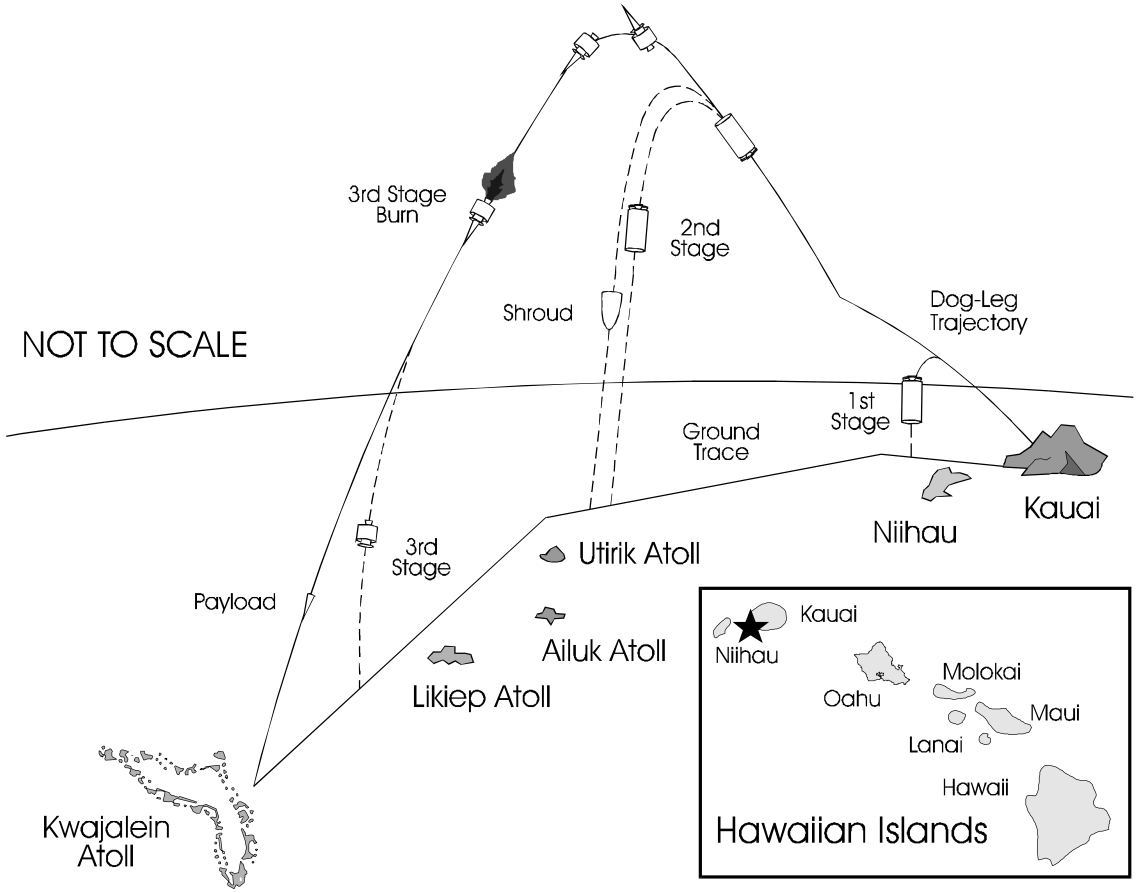

Figure 1.1-1 Typical Flight Profile for the STARS I Reentry Experiment Mission

1.2 PURPOSE

The purpose of this document is to provide data that pertains to the specific payload design, development, and field operation requirements that must be complied with by any payload designer that wants to use the STARS I booster. These data include interface requirements, environmental and structural loading requirements, dynamic requirements, ground and flight safety requirements, and interface testing requirements. No deviation from these requirements is permitted unless specifically authorized in writing by the USASSDC.

Additionally, general information on the description and capabilities of the STARS I rocket vehicle is included. These data are provided to acquaint payload designers with the system capabilities and limitations, and to aid them in employing the STARS I booster for their specific mission requirements. They are not imposed as a requirement for payload design and development.

1.3 SCOPE

This document defines typical STARS I capabilities and the payload-to-booster interface design compliance requirements (including design constraints related to STARS I environments, control dynamics, and range safety). The detailed descriptions of these requirements and capabilities are organized in the following sections of this handbook:

Section 2.	Vehicle performance and attainable reentry test conditions utilizing STARS I.
Section 3.	STARS I mechanical interfaces and related payload design compliance requirements.
Section 4.	STARS I airborne and ground electrical interfaces and related design compliance requirements for payload and support equipment.
Section 5.	Payload environment and loading conditions associated with prelaunch, launch and boost flight, and post-boost flight that payload designs must meet.
Section 6.	STARS I instrumentation and range Radio Frequency (RF) transmission link capabilities.
Section 7.	STARS launch complex and payload accommodations at KTF.
Section 8.	US Navy PMRF technical support capabilities.
Section 9.	All tasks required from payload integration through launch operations.
Section 10.	All tasks required for a flight test mission, including program management and range requirements.

1.4 LAUNCH VEHICLE CONFIGURATION

STARS I is a solid-propellant, three-stage, booster system that is 34 feet long, 54 inches in diameter and weighs approximately 36,000 pounds. It is inertially-guided, with optional position and velocity updates provided to its guidance system by the Global Positioning System (GPS). The STARS I vehicle general configuration is shown in Figure 1.4-1. The general vehicle and an optional longer version are shown in Figure 1.4-2. The booster system consists of a first stage rocket motor assembly, an interstage section, a second stage rocket motor assembly, a third stage motor assembly, and a nose fairing.

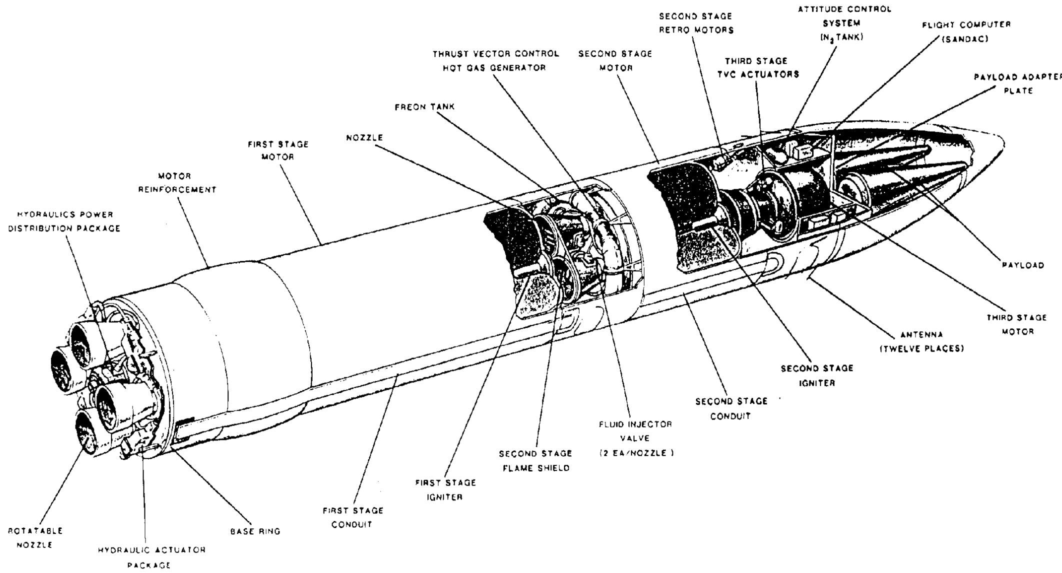

Figure 1.4-1 Strategic Target Systems (STARS) Cutaway Drawing

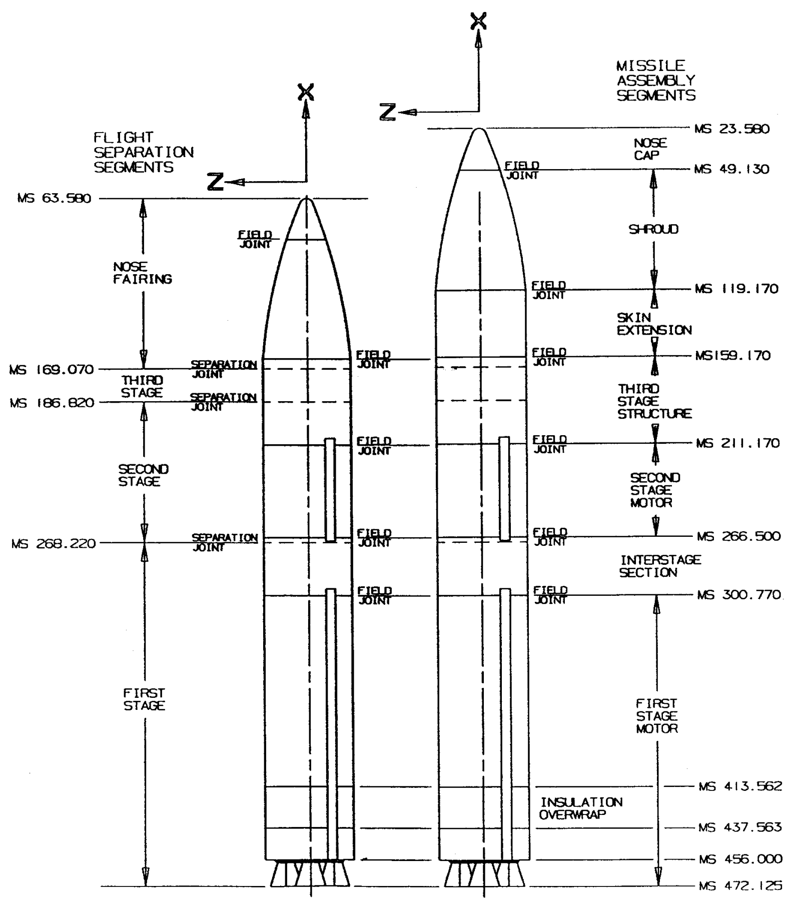

Figure 1.4-2 STARS I Missile Configurations

1.4.1 First Stage

The STARS I first stage (FS) rocket motor is a refurbished Polaris A3P FS motor. The stage is 182 inches (15.2 feet) long, 54 inches in diameter, and contains approximately 20,800 pounds of solid propellant (high explosive equivalency of 10,500 lbs TNT). Information concerning propellant formulation, performance, etc., can be found as Unit 376 of the *Chemical Propellant Information Agency (CPIA)/M1 Rocket Motor Manual*[2]. The STARS I FS motor assembly consists of an externally modified motor casing, an igniter assembly, four rotatable nozzle assemblies with hydraulic actuation for thrust vector control (TVC), and onboard flight termination system (FTS).

The motor chamber is a fiberglass filament-wound pressure vessel with skirts and bosses, filled with solid propellant. An external casing modification has been made to the motor case that consists of a 24 inch-wide composite overwrap, centered 31 inches forward of the aft skirt. The composite overwrap is a hot gas seal consisting of a casing bonded insulation blanket under fiberglass hoop wraps. Motors that are selected for flight have passed a full-body radiographic inspection.

The igniter assembly consists of a pyrotechnic igniter chamber and a new hot bridge-wire initiator. The STARS I missile uses a 28 volt initiator, Special Devices, Incorporated (SDI) part number 103377-166.

Four equally spaced rotatable nozzle assemblies are bolted to the nozzle bosses in the motor aft dome. The nozzles are controlled by individual hydraulic actuator packages (HAPs) that are powered by a hydraulic power distribution package (HPDP) centered on the aft dome. Prior to flight, the nozzles are removed from the candidate flight motor, recertified by leak and torque testing, and reinstalled. The HAPs and HPDPs are certified for flight by acceptance testing of the individual components and functional testing of the system.

The FS conduit cable is certified for flight by performing a continuity check on the individual contacts and functional testing with the rest of the system.

The FS FTS is located on the forward dome of the motor. The FTS consists of flexible linear shape charge (FLSC) bonded to the dome, two MC3644 detonators with attachment hardware, and the MA170 FTS electronics package with auto-destruct capability. The motor thrust can be terminated by cutting the fiberglass forward dome with the FLSC and venting the internal motor pressure.

1.4.2 Interstage Section

The STARS I interstage section (IS) is a modified Polaris A3 IS. It is a cylindrical shell made of a magnesium-thorium sheet, HK31A-H24, which is 54 inches in diameter and 34.3 inches long. The first stage motor ignition umbilical interface is on the IS. A mild detonating fuse (MDF) is installed around the forward circumference of the section to separate the first stage and interstage from the rest of the missile after first stage burnout. The MDF

[2] The John Hopkins University, Applied Physics Laboratory, *Chemical Propellant Information Agency/M1 Rocket Motor Manual*, latest release.

is initiated by two MC3644 detonators. The interstage section contains an A3 Hydraulics Battery for powering the FS TVC. The original A3 interlocks have been removed.

1.4.3 Second Stage

The STARS I second stage (SS) rocket motor is a refurbished Polaris A3P SS motor. The stage is 89 inches (7.4 feet) long, 54 inches in diameter, and contains approximately 8,800 pounds of solid propellant (high explosive equivalency of 8712 lbs TNT). Information concerning the propellant formulation, and thrust can be found as Unit 411 of the *CPIA/M1 Rocket Motor Manual*. The STARS I SS motor assembly consists of a modified motor chamber, an igniter assembly, four fixed nozzle assemblies with liquid injection for TVC, and an onboard FTS.

The motor chamber is a fiberglass filament-wound pressure vessel with skirts and bosses that is filled with solid propellant. The chamber modification is internal in the forward dome region. The refurbishment modifications involve draining the liquefied potting out of the gap between the chamber insulation and the propellant shrinkage liner; repotting the gap with a silicone material; and replacing the rigid potting containment device with a flexible potting containment baggie. The baggie collects residual liquefied potting and prevents the potting from contacting the propellant.

The igniter assembly consists of an igniter chamber and a new hot bridge-wire initiator. The main charge of propellant in the igniter has the basic chemical properties of the SS motor propellant. The STARS I missile uses a 28 volt initiator (SDI part number 103377-166). The SDI initiator also ignites the hot gas generator (HGG) in the SS TVC system.

Four equally spaced, fixed nozzles are attached to the nozzle ports by retaining rings. The flight motor candidates are received and x-rayed without nozzles installed. The nozzles are inspected separately, refurbished (if required), and certified for flight prior to installation.

The SS liquid TVC system consists of four injector valve assemblies, a manifold assembly, a toroidal fluid filled tank, a HGG, and a hot gas relief valve. Second stage thrust deflections are accomplished by injecting fluid into one side of a fixed nozzle to create a shock wave. Nozzles 1 and 3 are used for pitch control while nozzles 2 and 4 are used for yaw control. Roll control is accomplished using all nozzles. All TVC components are certified for flight by inspection and acceptance testing. The manifold and injectors are functionally tested with nitrogen during assembly and final systems checkout.

A new SS conduit cable is required for STARS flight. This cable is certified for flight by performing a continuity check on the individual contacts and functional testing with the rest of the system.

The SS FTS is located on the forward dome of the motor. The FTS consists of FLSC bonded to the dome, two MC3644 detonators with attachment hardware, and the MA170 FTS electronics package with auto-destruct capability. The motor thrust can be terminated by cutting the fiberglass forward dome with the FLSC and venting the internal motor pressure.

1.4.4 Third Stage

The STARS I third stage (TS) assembly, shown in Figure 1.4-3, is a new design replacing the old Polaris A3 equipment section (ES). The TS consists of an electronic component section with payload plate, an Orbus 1 motor, and an interstage between the second and third stages. The new TS is 52 inches long, which is 20.33 inches longer than the Polaris ES, and 54 inches in diameter. The TS length can be extended an additional 40 inches to accommodate larger payloads. This longer version of STARS I is shown in Figure 1.4-2. The skin consists of a 0.160 inch magnesium-aluminum alloy sheet, AZ31B-H24. A 0.030 inch thick coating of Dow Corning 92-009 applied to the exterior surface of the TS protects the magnesium skin from aerodynamic heating during the ascent through the atmosphere.

The TS electronic component section houses the STARS I missile electronics. The forward end of this section is defined by the magnesium payload plate, and the aft end by the lower MDF separation system. The three missile umbilical interfaces, including the pay-

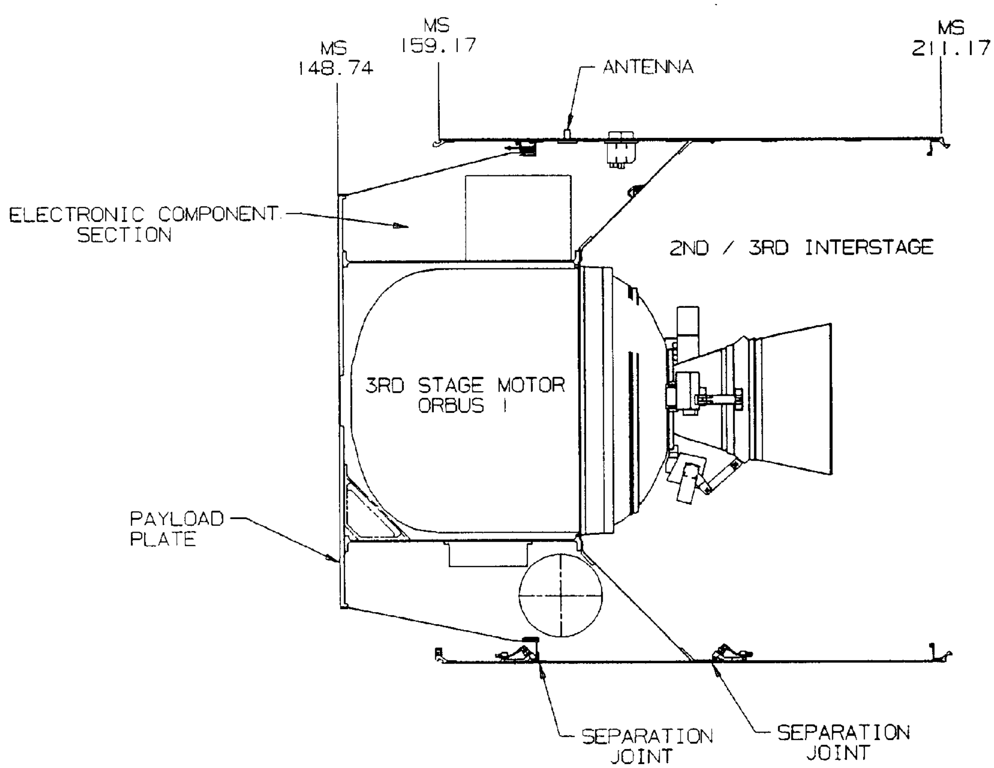

FIGURE 1.4-3 STARS I Third Stage Assembly

load systems umbilical, are located here. The electronic systems housed in this section include:

- Navigation Guidance and Control (NG&C) system with an inertial measurement unit (IMU), a Sandia Digital Airborne Computer (SANDAC), the TVC packages, and a GPS package.
- Arm and Fire (A&F) system with a programmable sequencer.
- Telemetry (TM) and S-band antennas.
- C-band transponder with antenna.
- Power and signal distribution for the missile electronics, including batteries and switches.
- Attitude Control System (ACS) with pneumatics.
- FTS command receivers and command destruct packages with ultra high frequency (UHF) antennas.

The STARS I system is designed to allow up to four retro motors to be mounted on the payload plate. These are used to provide adequate spatial distance between the separated payload(s) and the expended third stage motor. The number of retro motors used is dependent on the specific mission requirements. Information on propellant formulation and thrust for the retro motor, SR11-HP-1, can be found in Unit 503 of the *CPIA/M1 Rocket Motor Manual*.

The Orbus 1 motor is a new motor with TVC designed for STARS to SNL specifications by United Technologies Corporation, Chemical Systems Division (UTC/CSD). The motor is 49.2 inches long and 27.2 inches in diameter. It contains approximately 910 pounds of UTP-19687A solid propellant (high explosive equivalency of 920 lbs TNT) with an HTPB binder. Information concerning the propellant formulation, motor performance, etc., can be found in the *Orbus 1 Motor Program Development and Qualification Report*[3]. The Orbus 1 motor assembly consists of a graphite composite case, an igniter assembly, a nozzle assembly with a flexseal joint, a TVC system with thermal battery, and an onboard FTS. The igniter assembly is a toroidal pyrogen igniter initiated by dual Teledyne McCormick Selph electric low voltage detonators, part number 817447. During third stage burn, vehicle pitch and yaw are controlled with the motor TVC system. Roll attitude is controlled during burn using the cold gas ACS.

The Orbus 1 FTS is located on the aft dome of the motor. The FTS consists of FLSC bonded to the dome and two MC3644 detonators with attachment hardware. The motor thrust can be terminated by cutting the graphite aft dome with the FLSC to separate it along with the nozzle assembly from the rest of the motor.

[3] United Technologies Chemical Systems, *Orbus 1 Motor Program Development and Qualification Report Contract Numbers 23-0957 and 75-4931*, June 1990.

There are two MDF systems installed around the circumference of the TS. The forward system separates the nose fairing from the TS. The aft system separates the lower part of the TS structure, the 2nd/3rd-interstage, and the SS motor from the rest of the TS. Two SS retro motors are located in this lower section. Each MDF system is initiated by two MC3644 detonators.

1.4.5 Nose Fairing

The STARS nose fairing (NF) is a modified Polaris A3 NF. It is fabricated using a laminated wood and aluminum structure which protects the payloads during the launch and boost phase of flight through second stage burnout. A 0.010 inch thick Dow Corning 3145 protective coating has been added to the exterior surface for thermal protection during ascent through the atmosphere. The Polaris nose fairing jettison motor, motor mounting hardware, and high energy firing unit are no longer used and have been removed. The STARS NF is spring ejected with a separation velocity of approximately 1.5 feet per second. Higher NF separation velocities are possible.

1.4.6 Missile Coordinate System

The STARS I missile utilizes a right-handed rectangular coordinate system as seen in Figure 1.4-4. The origin is located on the missile centerline 63.58 inches forward of the tip of the NF. The longitudinal axis (x) is positive forward. The absolute value of its x coordinates are designated as missile station (MS) values. The y-axis is positive right (0 degrees)

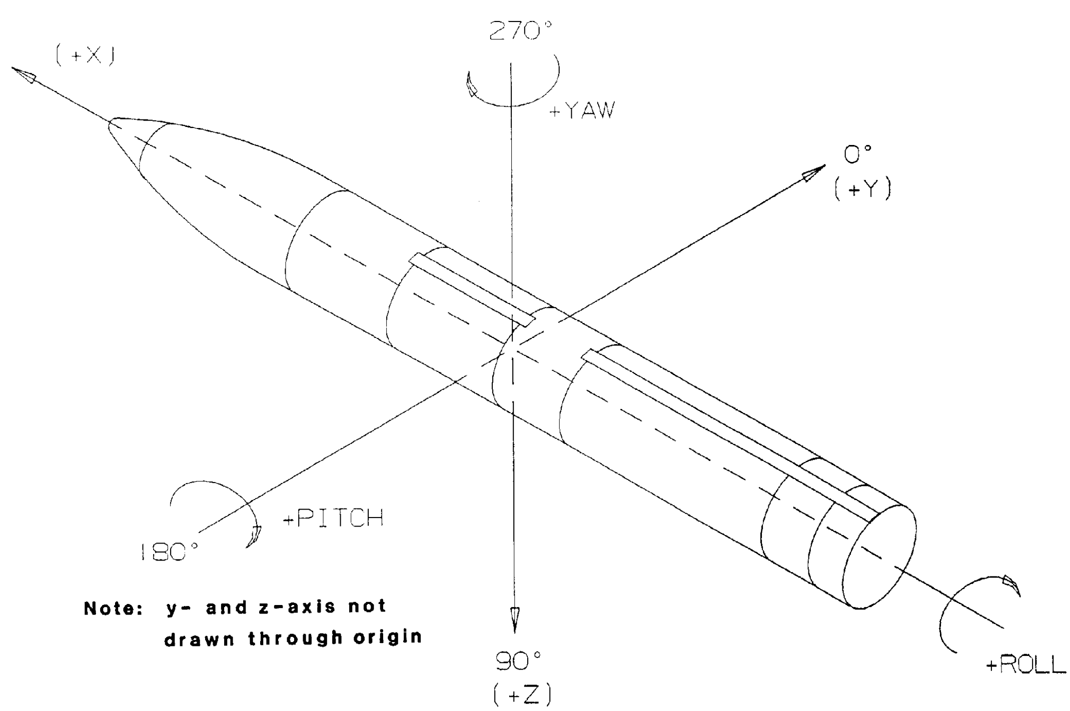

Figure 1.4-4 Missile Coordinate System

when viewed from the aft end. The z-axis is positive down (90 degrees). This coordinate system is used for locating positions on the missile.

The vehicle motions of +pitch, +yaw, and +roll are also defined in Figure 1.4-4. Positive pitch is defined as nose up, positive yaw as nose-to-the-right when looking forward, and positive roll as clockwise looking forward along the x-axis.

1.5 NAVIGATION, GUIDANCE AND CONTROL SYSTEM (NG&C)

The STARS I NG&C system is implemented with new, state-of-the-art components and subsystems. Only the electrohydraulic and electromechanical components from the Polaris A3 first and second stage TVC systems have been retained. Likewise, the guidance and flight control techniques and algorithms used are new. The Polaris first stage guidance and trajectory shaping algorithms have been retained. All algorithms and techniques which are used from first stage burn-out and separation through the remainder of the flight are new.

An important objective of the NG&C development effort was the implementation of a system which would meet anticipated mission accuracy requirements with a high reliability. Various mission objectives required a flexible, adaptable design. The approach taken has been to use a production, military spec quality ring laser gyro IMU; and a high performance, easily programmable flight computer.

Figure 1.5-1 shows a block diagram of the STARS I NG&C system. The diagram shows the basic design and architecture, and the major subsystems. All navigation, guidance and flight control algorithms are implemented in the SANDAC V flight computer. The subsystem hardware elements are described in Subsection 1.5.1. The system algorithms and the operational characteristics of the system are described in Subsections 1.5.2 and 1.5.3.

1.5.1 NG&C Subsystems

The STARS I NG&C system consists of the following hardware elements:

1. Flight Computer - The flight computer, a SANDAC V, is a modular high performance computer which is the fifth in a series of computers developed primarily for SNL exploratory development programs and maneuvering reentry vehicle applications. The STARS I configuration of this computer consists of a utility module; a system I/O module which acts as an interface with the IMU, a GPS receiver, and ground support systems; a MIL-Std-1553B bus module which provides an interface with the vehicle TM system, the A&F sequencer, and is also available as an interface to the payloads; and three processor modules. Each processor module includes a Motorola 68040 microprocessor and 512K of CMOS static RAM which serves for both program and data storage.

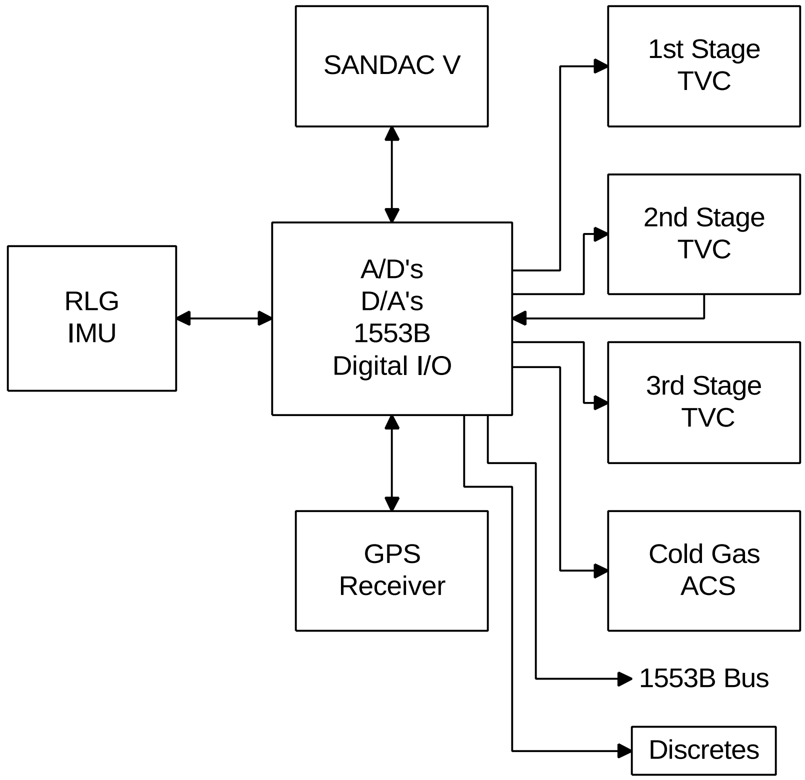

Figure 1.5-1 Block Diagram of STARS I Guidance and Control System

2. Inertial Measurement Unit - The STARS IMU is a modified version of a Honeywell HG1066 inertial navigation system. This system uses the Honeywell GG1342 ring laser gyro and Sundstrand QA2000 servo accelerometers. The instrument sensor assembly in the system is common to three military navigation systems: the Air Force's F-15 Inertial Navigation System (INS); the Air Forces's Standard Navigator which is used on a number of aircraft; and the Army's Modular Azimuth Positioning System (MAPS) system which is used for land navigation applications. The STARS IMU is a modified production version of the MAPS system. After delivery, the processors are replaced by the SANDAC interface electronics. Two vehicle interface cards are also installed in the IMU. They include the A/D and D/A converters and various other input/output functions. The cover is modified to allow for pressurization of the package and space for an additional connector.

3. GPS System - The GPS system is comprised of a Texas Instrument (TI) GPS Embedded Module (GPSEM), a TI dual L-band flight preamplifier, a 3-pole pin diode RF switch and two L-band patch antennas. The accuracy of the STARS I ring laser gyro IMU is sufficient for currently defined mission requirements. Should higher guidance accuracy or more precise trajectory information be required, the guidance steering loop can be closed around a six channel P-code GPS receiver. This receiver is fully integrated with the inertial navigation system and provides precision GPS data during both the ballistic and boost phases of the flight.

4. First Stage Thrust Vector Control - The first stage TVC system uses original Polaris A3 HAPs. Each of the four first stage nozzles are moved by a self-contained hydraulic actuator which includes a reservoir, an electrically operated hydraulic pump, and the required servo valves and transducers. The A3 servo electronics has been replaced with newly designed electronics. The actuators are powered with an explosively initiated silver zinc battery which is activated during the terminal countdown sequence. They are driven by D/A converters located in the IMU package.

5. Second Stage Thrust Vector Control - The second stage TVC system uses the Polaris A3 liquid injection system. Liquid injection is controlled by servo valves. The servo electronics which control the system have been redesigned for STARS.

6. Third Stage Thrust Vector Control - The Orbus 1 motor includes a single movable nozzle with two degrees of freedom. The nozzle is positioned by two electromechanical actuators powered by a thermal battery.

7. Cold Gas Attitude Control System - Vehicle attitude during coast phases of the flight and vehicle roll during the third stage burn are controlled by a cold gas system which includes nitrogen tanks, a regulator, a manifold, and thrusters. The thrusters are controlled by individual solenoid valves, which are controlled by discretes from the flight computer through valve driver electronics. The thrusters are configured to provide three axis attitude control. If required, a small delta velocity capability for payload release is available.

Other elements utilized by the NG&C system are:

1. Telemetry - The flight computer is interfaced to the vehicle TM system through the Mil-Std-1553B bus. A portion of the TM Pulse Code Modulation (PCM) format has been allocated to the NG&C system. The data inserted into this part of the format is specified in flight software and may include any data available in the computer.

2. Mode Control - The operational mode of the guidance system is controlled by discrete inputs provided by the range computer through the vehicle umbilical. Discrete outputs controlled by the flight computer are included in the interlocks. These outputs inhibit arming the first stage fire sets.

1.5.2 NG&C System Design and Algorithms

All required navigation, guidance, and flight control functions are implemented in the flight computer. These algorithms are programmed almost entirely in the "C" programming language. The flight software is loaded through the vehicle umbilical. An extensive capability for diagnostics and monitoring is also available through this path.

A well proven set of navigation algorithms processes data from the IMU and computes the position, velocity, and attitude of the vehicle in several coordinate systems. Kalman filter based auto alignment algorithms are used to initialize the navigation system during the count-down prior to launch.

A 13-state Extended Kalman filter is implemented which processes GPS receiver range and range-rate measurements to estimate the IMU position, velocity, and attitude errors. These errors are externally combined algebraically with the stand-alone IMU solution to form a corrected IMU solution. The corrected IMU solution is fed back to the receiver to aid the code and carrier tracking loops. This helps the receiver maintain phase lock on the GPS satellite signals during times when the vehicle is undergoing high dynamics. The cor-rected IMU solution is also potentially available to send to the guidance steering loops for enhancing the vehicle targeting accuracy.

Three guidance modes are used during the STARS I flight[4]. Various portions of the flight trajectory utilizing these modes are:

1. First Stage - The first 50 seconds of STARS I flight are controlled by algorithms which are based on the approach used in the A3. The vehicle is controlled to maintain a vertical attitude until the pitch over is enabled. The pitch profile is controlled by trajectory shaping parameters which are selected before flight.
2. Staging - At launch +50 seconds, the guidance commands are inhibited and vehicle angle of attack is controlled to minimize staging transients and second stage TVC fluid consumption.
3. Second Stage - At second stage ignition +10 seconds, the guidance commands are re-enabled. An adaptation of the Space Shuttle Powered Explicit Guidance algorithm is used to change the plane of the trajectory if required and control the second stage burn until guidance is again inhibited for second stage burn-out. Guidance velocity control via thrust termination is not available.
4. Third Stage - During the coast phase between second and third stage burns, a Lambert targeting algorithm is executed and the third stage ignition time required for the final target conditions is computed. The third stage ignition time may be varied to reduce time of flight dispersions, or may be held fixed to provide a simpler and more consistent sequencing of events. After third stage ignition, the guidance parameters are updated periodically. If an additional plane change is required, it is implemented after the computed impact point reaches a pre-specified set of conditions. Once again, guidance is inhibited before burn-out and thrust termination is not available for velocity control.

1.5.3 Operations

During preflight testing, evaluation, and flight code loading, the NG&C system is controlled and monitored through a gateway computer in the Launch Operations Building (LOB). The modes of the system during normal pre-launch countdowns are controlled by discretes which are set by the ground launch computer. Once launched, the baseline system is autonomous and only the command enable of third stage firing is required for com

[4] White, J. E., *Guidance and Targeting for the Strategic Target System*, Journal of Guidance, Control, and Dynamics, Volume 15, No. 6, Nov-Dec 1992, pp1313-1319.

pletion of the flight sequence. For future missions, options are being considered for providing an uplink capability for guidance or target updates.

1.6 SYSTEM FLEXIBILITY

The entire STARS system, including the vehicle, the ground systems, and the supporting organization, have been designed to provide the flexibility required for R&D flight testing activities. The relatively large diameter of the vehicle, the shape of the nose shroud and the flat payload plate make STARS I suitable as the carrier vehicle for a variety of payloads. The design and the easy accessibility of the missile electronics minimizes the time and cost required for any modifications that might be required for supporting a particular mission. A large part of the data that flows between the NG&C system, the flight sequencers and the TM encoders is routed via a Mil-Std-1553B data bus. This potentially allows ready access to data from the NG&C system and access to digital TM channels. The TM encoder also includes analog channels (through the encoders A/D converters) that may be available for payload use.

The NG&C system has been designed to allow maximum flexibility while minimizing mission specific costs. The guidance algorithms include explicit trajectory shaping and tageting features that allow easy mission specific programming. The flight computer is modular and can be reconfigured to support mission requirements. Flight software is stored in RAM and is loaded during the countdown from consoles in the LOB. The capability for uploading data or mission parameters during the countdown is also available. Facilities for validation of the flight software and allowable mission parameters are located at SNL in Albuquerque. Final flight software validation will generally be conducted thirty to sixty days before a planned launch operation.

The STARS ground support systems and the facilities provided by KTF and PMRF allow considerable flexibility in mission planning and flight operations. Links that allow real-time access to tracking radar and TM data are available. There is also ready access to other Hawaiian area assets such as the Air Force Maui Optical Station (AMOS).

2. STARS I FLIGHT PERFORMANCE

This section describes the types of missions that can be flown using the STARS I booster system. The information presented in this section is meant to provide an overview of the booster system's capabilities. The payloader is invited to contact the Strategic Targets Product Office in Huntsville to obtain help in planning their mission or in procuring other trajectory support.

2.1 STARS I MISSION DESCRIPTIONS

This section describes different types of missions that can be conducted using the STARS I missile system. An overview of the mission timeline associated with conducting these missions is also discussed.

2.1.1 Reentry Mission

A representative STARS I mission for a launch from the Kauai Tests Facility (KTF), Kauai, Hawaii, into the vicinity of the US Army Kwajalein Atoll is depicted in Figure 2.1-1. In this case, the payload is a reentry vehicle (RV) or vehicles. The mission profile for this type of experiment is optimized to produce the maximum velocity at a specified vertical flight path angle (reentry angle) at the time and location of reentry. An example STARS I timeline for this type of mission is shown in Table 2.1-1. This timeline includes several prelaunch ground events as well as the typical flight events. This type of mission generally requires two turns, or "doglegs", during the course of the flight to insure the vehicle's in-

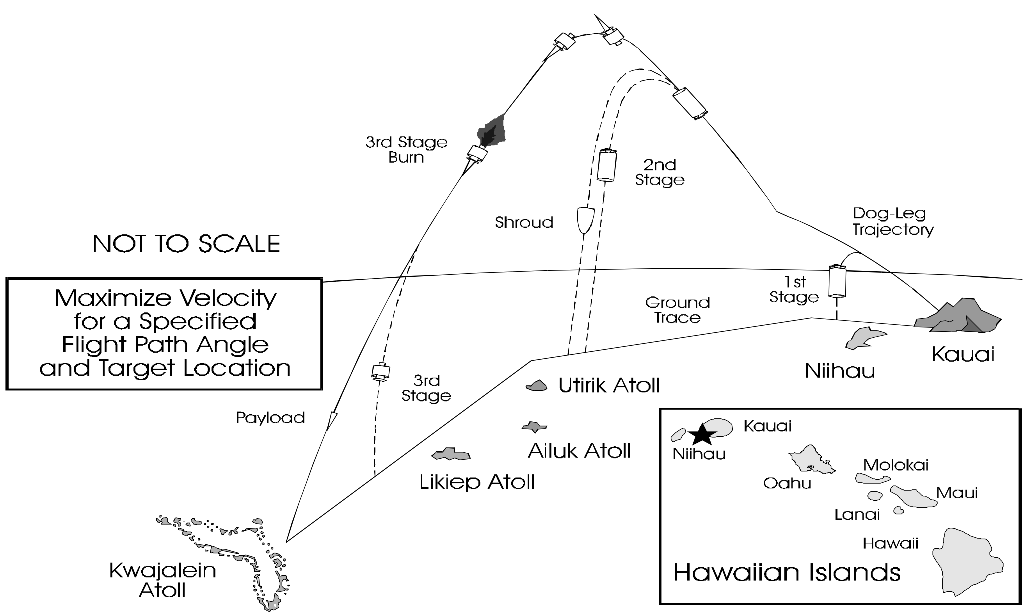

Figure 2.1-1 STARS I Reentry Mission (Mission Type I)

stantaneous impact point (IIP) does not cross over any populated landmass. The initial fly-out from KTF ensures adequate separation between the STARS IIP track and the is-land of Niihau. The first "dogleg", which occurs during the second stage burn, is required to turn the vehicle from the initial KTF fly-out azimuth towards KMR. If the second “dogleg” is re-quired for safety, it will occur during the third stage burn after the IIP has passed to the north of Utirik Atoll. The payload is then separated from the third stage af-ter Orbus 1 burnout at the proper attitude to produce the desired total angle of attack condition at reentry.

Table 2.1-1 STARS I Mission Type I Representative Timeline

Event No.	Nominal Time (Sec TALO)	Event Description
1	-3600.0	Apply system power & verify basic system functionality
2	-3480.0	Load flight software if required or verify loaded software integrity
3	-1800.0	Initiate INS alignment & verify IMU performance
4	-300.0	Switch flight termination system to internal power
5	-210.0	Switch main electronics to internal
6	-90.0	Initiate flight alignment sequence
7	-45.0	Switch Navigation Guidance & Control system to flight mode
8	-28.0	Begin 1st stage TVC system test
9	-17.0	Arm FTS & 1st stage booster
10	-2.0	Begin inertial guidance navigation
11	-1.8	Ground Launch Computer issues "launch ready" signal
12	0.0	Ignition signal sent from Ground Launch Computer
13	0.1	Lift-off (first motion)
14	1.5	Begin roll program to fly-out azimuth
15	2.0	End roll program
16	2.2	Begin pitch program
17	39.0	Maximum dynamic pressure
18	50.0	Begin angle of attack control
19	58.7	Hot gas generator initiation (3.49 g's decreasing)
20	61.0	Arm 1st stage separation & 2nd stage ignition (1.24 g's decreasing)
21	61.3	1st/2nd Staging, 2nd stage ignition, 2nd stage autopilot on
22	61.7	2nd Stage at full thrust
23	81.3	End angle of attack control & begin Niihau dog-leg turn
24	138.8	2nd Stage burnout and separation, 2nd stage retro fire, & ACS activated
25	170.0	Ascent shroud jettison
26	180.0	Begin 3rd stage targeting & ACS maneuver to 3rd stage burn attitude
27	210.0	3rd Stage pointing maneuver completed
28	513.0	Apogee (358 nm)
29	<518.0	Command to enable 3rd stage motor ignition is sent
30	575.0	Begin tight deadband control in ACS pointing
31	582.0	3rd Stage thermal battery activated
32	584.0	Pitch and yaw ACS deactivated, 3rd stage guidance and autopilot activated
33	585.0	3rd Stage ignition
34	624.7	3rd Stage burnout & ACS reactivated (0.1 g's decreasing)
35	654.7	Begin reentry prediction calculation
36	663.0	Begin ACS maneuver to payload release attitude
37	703.0	End ACS maneuver & release payload
38	713.0	Begin ACS maneuver to retro fire attitude
39	753.0	End ACS maneuver & fire retro motor(s)
40	1016.4	Payload reenters at 300 Kft altitude

2.1.2 Altitude Requirement and Reentry Mission

For the second type of mission, an altitude requirement and a desired target location would be specified. The target location can occur anywhere along the trajectory profile. This type of mission is shown pictorially in Figure 2.1-2. A mission of this type might occur if there were to be an I nteraction between a STARS payload and a satellite during the midcourse portion of the flight, followed by an additional experiment occurring at reentry later in the flight. Increased downrange impact dispersions for this type of mission will generally require a nominal impact point that is farther away from Kwajalein Atoll as compared to a Type I mission scenario. The requirement to achieve a specific altitude means the payload will reenter at a lower velocity and/or a steeper reentry angle than for the Mission Type I flight profile. A representative timeline is shown in Table 2.1-2. Note that this timeline is similar to the one shown for Mission Type I. However, the third stage will have to be fired much earlier in the timeline. The comments on "doglegs" made in Section 2.1.1 could also apply to a mission of this type, depending on the targeted point and the resulting downrange dispersion ellipse.

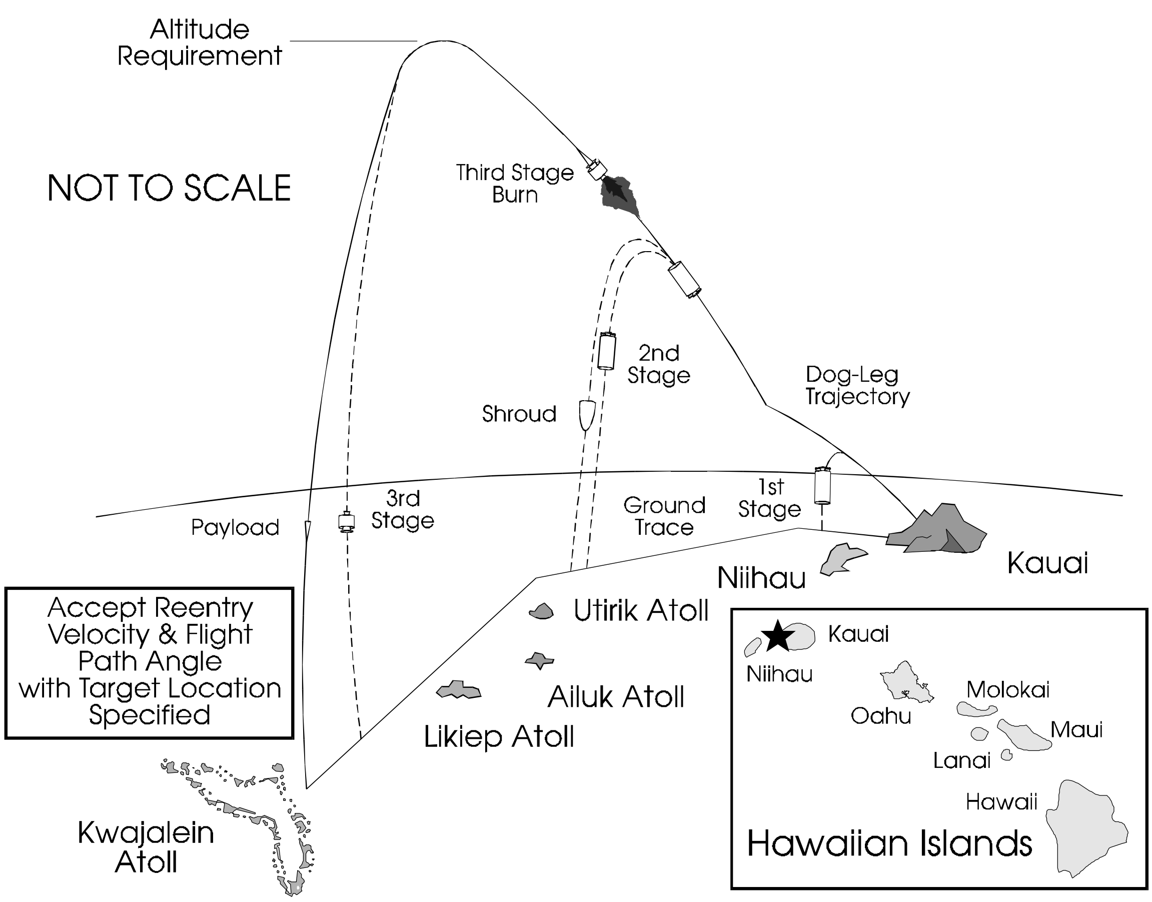

Figure 2.1-2 STARS I Reentry Mission with an Altitude Requirement (Mission Type II)

Table 2.1-2 STARS I Mission Type II Representative Timeline

Event No.	Nominal Time (Sec TALO)	Event Description
1	-3600.0	Apply system power & verify basic system functionality
2	-3480.0	Load flight software if required or verify loaded software integrity
3	-1800.0	Initiate INS alignment & verify IMU performance
4	-300.0	Switch flight termination system to internal power
5	-210.0	Switch main electronics to internal
6	-90.0	Initiate flight alignment sequence
7	-45.0	Switch Navigation Guidance & Control system to flight mode
8	-28.0	Begin 1st stage TVC system test
9	-17.0	Arm FTS & 1st stage booster
10	-2.0	Begin inertial guidance navigation
11	-1.8	Ground Launch Computer issues "launch ready" signal
12	0.0	Ignition signal sent from Ground Launch Computer
13	0.1	Lift-off (first motion)
14	1.5	Begin roll program to fly-out azimuth
15	2.0	End roll program
16	2.2	Begin pitch program
17	39.0	Maximum dynamic pressure
18	50.0	Begin angle of attack control
19	58.7	Hot gas generator initiation (3.49 g's decreasing)
20	61.0	Arm 1st stage separation & 2nd stage ignition (1.24 g's decreasing)
21	61.3	1st/2nd Staging, 2nd stage ignition, 2nd stage autopilot on
22	61.7	2nd Stage at full thrust
23	71.7	End angle of attack control & begin Niihau dog-leg turn
24	138.8	2nd Stage burnout and separation, 2nd stage retro fire, & ACS activated
25	170.0	Ascent shroud jettison
26	172.0	Begin 3rd stage targeting & ACS maneuver to 3rd stage burn attitude
27	188.0	3rd Stage Thermal Battery Activated
28	189.0	Pitch and yaw ACS deactivated, 3rd stage guidance and autopilot activated
29	190.0	3rd Stage ignition
30	229.6	3rd Stage burnout and ACS reactivated (0.1 g’s decreasing)
31	230.0	Begin ACS maneuver to payload (s)release conditions
32	513.0	Apogee (358 nm)
33	1016.4	Payload(s) reenter at 300 Kft altitude

2.1.3 Experiment Carrier Vehicle

A third type of mission would use the STARS I vehicle to loft a payload on a trajectory that will maximize the dwell time at exoatmospheric conditions. In addition to achieving an extremely high altitude, the trajectory must be designed to insure all stages impact in a safe area. For this type of mission, no doglegs would be required. The mission is shown pictorially in Figure 2.1-3. One example of a Type III mission involves operating a payload for a long period of time to do material processing experiments under microgravity conditions.

The timeline shown in Table 2.1-2 would be applicable for a Mission Type III. However, all references to doglegs should be ignored. The flyout azimuth from KTF would most likely be to the northwest, which is away from all populated areas.

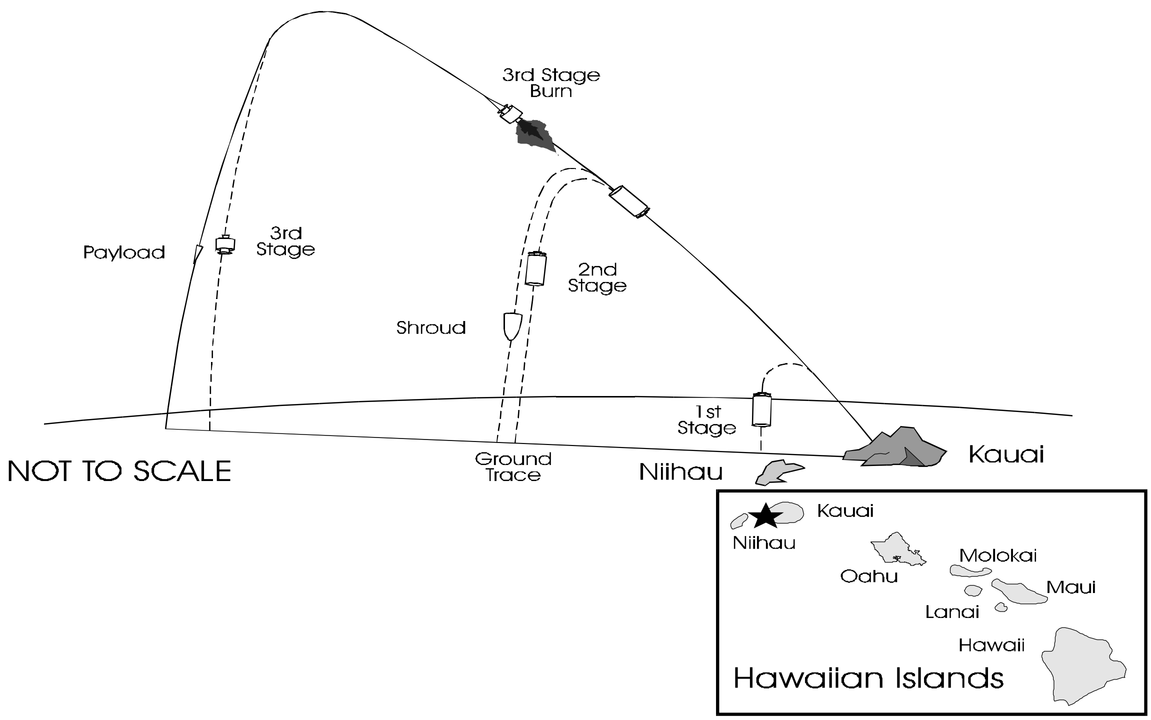

Figure 2.1-3 STARS I Experiment Carrier Vehicle (Mission Type III)

2.1.4 Theater Missile Defense (TMD) Target Vehicle

The operational flexibility of STARS allows the missile to be configured and flown as a target vehicle for TMD applications. These configurations and applications include:

1. The complete STARS I vehicle to simulate the longer range TMD threats with an approximate range of 2500 to 3000 km.
2. The STARS first stage to fly heavy TMD target payloads on missions with an approximate range of 100 to 1000 km, dependent on ballast weight and altitude requirements.
3. The STARS first and third stages to fly heavy TMD target payloads on 100 to 1000 km range missions requiring upper stage maneuvering, tight targeting accuracy, or in-flight adjustments of terminal entry conditions (i.e. the “pile driver” or “double arches” concepts).

Initially, some development effort would be required to provide the configurations outlined in items 2 and 3. Also, the possibility exists that all three configurations could be flown from launch sites other than KTF.

2.1.5 Range Safety Constraints

The experimenter should keep in mind that the "doglegs" are required to satisfy range safety requirements, and they must be considered for all missions going into the KMR area. Since they affect the overall delivery capability of the STARS I vehicle, a compromise between payload weight, reentry requirements, target location, and flight safety must be maintained. The missions presented in this handbook are meant to be representative of the types of mission profiles that the STARS vehicle is capable of completing. Help in planning a mission and/or in constructing flight profiles is available through the cognizant departments at SNL by submitting a request to the Strategic Targets Product Office in Huntsville, AL.

2.1.6 First Stage Flight

The STARS launch commences with the ignition of the first stage motor. First motion is sensed with the umbilical pullout shortly after motor ignition. Vehicle control is maintained during the first stage flight through the use of four rotating nozzles. A roll maneuver is initiated approximately 1.5 seconds after lift-off to align the missile z-axis with the fly-out azimuth. This azimuth angle is typically on a heading angle of 275º True. At 2.2 seconds, a pitch-over maneuver begins to turn the missile downrange while keeping the angle of attack small to minimize the effects of aerodynamic loading. The loft of the trajectory during the atmospheric portion of the ascent is controlled by parameters that are entered into the flight guidance computer. Near the end of the first stage burn, a hot gas generator is initiated to pressurize the second stage TVC fluid injectant tank. Separation between the first and second stages is initiated when the axial acceleration indicates the first stage burn is nearly complete (<1.2 g's decreasing). The sequence of events listed for the first stage portion of flight will be the same for each of the three mission types discussed previously.

2.1.7 Second Stage Flight

Second stage ignition occurs simultaneously with the staging event. A fluid injection system provides the mechanism for control during second stage flight. The missile continues along the fly-out azimuth during the early portion of the second stage burn. For the Type I and II scenarios, the first dogleg is initiated to turn the missile onto a trajectory towards the intended target once the IIP has passed by Niihau. The time and turning rates used to make the dogleg are determined on a mission by mission basis by TVC consumables and autopilot stability margin constraints. The turn is typically initiated 10 to 20 seconds after second stage ignition. In addition to the turn, the booster is steered as closely as possible to the nominal post burnout trajectory. Since none of the STARS stages have thrust cut-off or other velocity control capability, off nominal motor performance will produce post burnout trajectories that are slightly different than nominal. Separation between the second and third stages occurs when the longitudinal acceleration falls below a specified level (<0.1 g's). Two retro motors located at the front of the expended second stage motor are ignited simultaneously with the staging event to insure adequate separation between the second and third stages.

For the Type III profile, no dogleg is required, and the second stage will continue to burn in a direction along the fly-out azimuth. Once the dynamic pressure falls to a sufficiently low value, a pitch up maneuver will begin that will increase the velocity in the vertical direction. As in the Type I and II scenarios, the TVC consumables and autopilot stability margins will dictate the maximum rate the vehicle can be pitched up. An additional constraint will be imposed by range safety in specifying the allowable impact location for the expended second stage booster. The staging event for a mission of this type will be the same as described previously.

2.1.8 Third Stage Flight

Coincident with the staging event between the second and third stages, the cold gas ACS is activated on the third stage. This system is active during the coast phase, and is used to keep the third stage stable as well as to reorient the stage to the proper attitude prior to the ignition of the third stage motor. During the coast phase between staging and third stage ignition, the nose fairing is ejected with springs that impart a small delta-velocity. The third stage, Orbus 1, is then oriented to the attitude required for third stage ignition.

For a Type I mission, third stage ignition will typically occur post apogee. The delayed ignition time on the third stage allows improved accuracy in the position and velocity achieved at reentry. Additional improvements in the reentry delivery conditions can also be achieved if the time of third stage ignition is allowed to vary to compensate for dispersions that occur during the first two stage burns. In some cases, a flight safety hand-off from the Pacific Missile Range Facility (PMRF) to KMR range safety may be required. In these cases, KMR range safety will issue a command to enable the firing circuits on the third stage during the coast phase prior to third stage ignition.

For Type II and III missions, third stage ignition will occur shortly after second stage separation when the vehicle has been oriented to the proper attitude. The coast time between events will be determined by detailed simulations of the required ACS maneuvers. The experiment objectives will dictate how the third stage motor is pointed during the burn. In either case, satisfying the mission altitude requirement will be the primary goal.

During the third stage burn, control of the missile is provided by an electrically actuated TVC system that is capable of providing steering in both the pitch and yaw directions. Approximately 3 seconds prior to third stage ignition, a thermal battery is activated to provide power to the TVC system. For the reentry type of mission, the third stage is generally targeted to fly north of the intended target point to insure the IIP is clear of the keep out areas surrounding the atolls of Ailuk, Utirik, and Likiep. Once the IIP passes by these atolls and into a safe corridor to the target point, the second dogleg can be initiated. This typically will occur midway through the third stage burn. Since the third stage lacks a velocity control capability, off nominal performance during the third stage burn will result in a small miss distance at the target. The expected errors at the target point will be discussed in Section 2.3.1.

Once the third stage has burned out, the ACS pitch and yaw control loops are again activated (the roll control loop of the ACS was on during the third stage burn to remove any roll torques produced while the motor was burning). The ACS is then used to orient the third stage to the required attitude prior to the release of the payload(s) from the third stage. After all of the payloads have been released, the third stage is reoriented to a retro fire attitude and the retro motor(s) are fired to provide separation between the payloads and the third stage. The payload and third stage separation capabilities will be discussed in more detail in Section 2.5.

2.2 TRAJECTORY AND FLIGHT PERFORMANCE INFORMATION

The information provided in this subsection provides an overview of the test conditions that one can achieve using the STARS I vehicle. Information for three possible mission scenarios is provided in this subsection. These include:

1. Maximum velocity reentry into the vicinity of KMR with the reentry location specified.
2. Maximum altitude followed by a reentry into a target area close to KMR.
3. Maximum altitude and data gathering time for a given weight payload.

All trajectories were generated using the WGS-84 earth model and a 15 degree north latitude annual atmosphere.

2.2.1 Reentry Mission into KMR (Mission Type I)

This is the type of mission for which the STARS I vehicle was originally designed. The objective for this type of mission is to re-enter a payload or payloads at the highest velocity possible at the desired reentry flight path angle. In addition to the reentry angle, the latitude and longitude position for the reentry would be specified. Several representative trajectories have been completed to illustrate the typical reentry conditions that might be achieved using the STARS I system. The following assumptions were made in generating the results that will be presented:

1. Only the first dogleg to avoid Niihau is required.
2. Payload reentry occurs at an altitude of 300,000 ft.
3. The nominal impact position was set to 169º E. longitude and 11.5º N. latitude. This location is approximately 150 nm northeast of the sensor platforms located on Roi Namur, KMR.

The TSAP[5] trajectory program was used to generate the trajectory results. These data are shown for a 300 lb payload with a trajectory loft guidance parameter (SKU) of 40. The

[5] Outka, D. E., *Trajectory Simulation and Analysis Program,*, Sandia National Laboratories, SAND 88-3158 Revised UC-905, July 1990.

specified reentry angle was -30°. The variation of altitude with time and range is presented in Figures 2.2-1 and 2.2-2, respectively. The ground track is shown in Figure 2.2-3. Also shown in this figure is the IIP trace for a ballistic coefficient of 400 lb/ft^2. The variations of velocity, acceleration, and Mach number are shown as a function of time in Figures 2.2-4 through 2.2-6.

Summary plots of the reentry velocity at 300 Kft as a function of reentry flight path angle are shown for SKU = 0 in Figure 2.2-7. Similar data for SKU = 20 and SKU = 40 are plotted in Figures 2.2-8 and 2.2-9, respectively. For the range of SKU numbers presented, the higher SKU's result in a higher velocity at reentry for a given reentry angle.

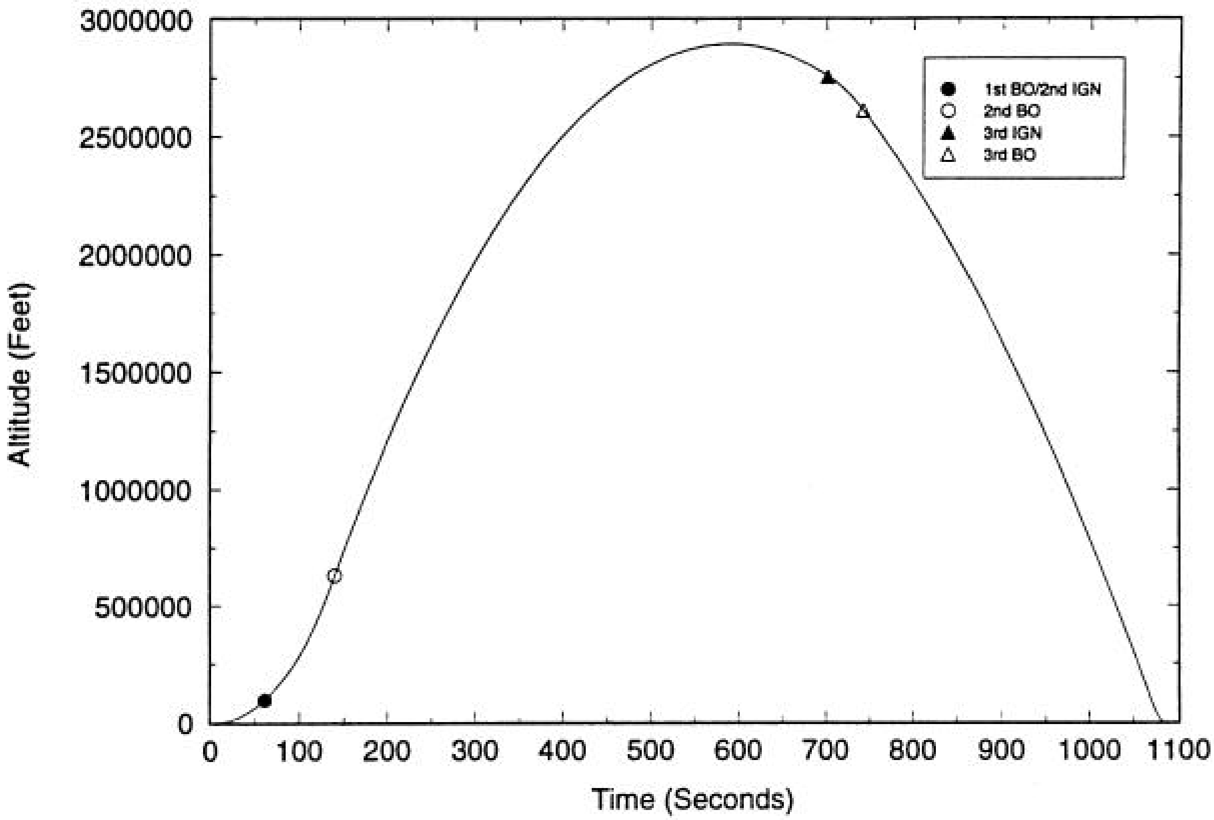

Figure 2.2-1 Altitude versus Time for a STARS I Vehicle Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

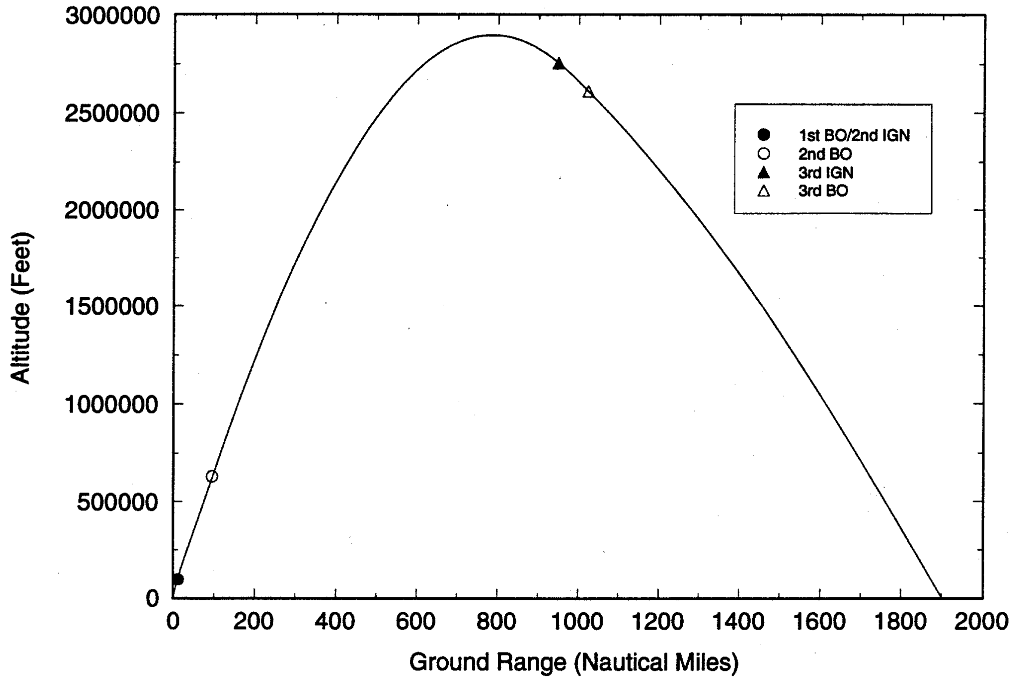

Figure 2.2-2 Altitude versus Ground Range for a STARS I Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

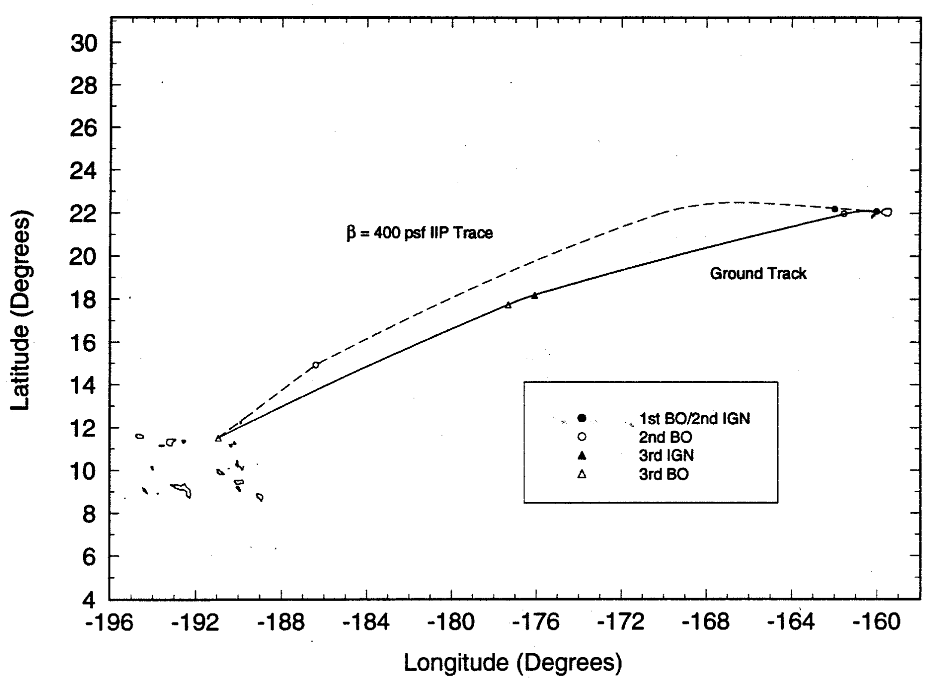

Figure 2.2-3 Ground Track for a STARS I Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

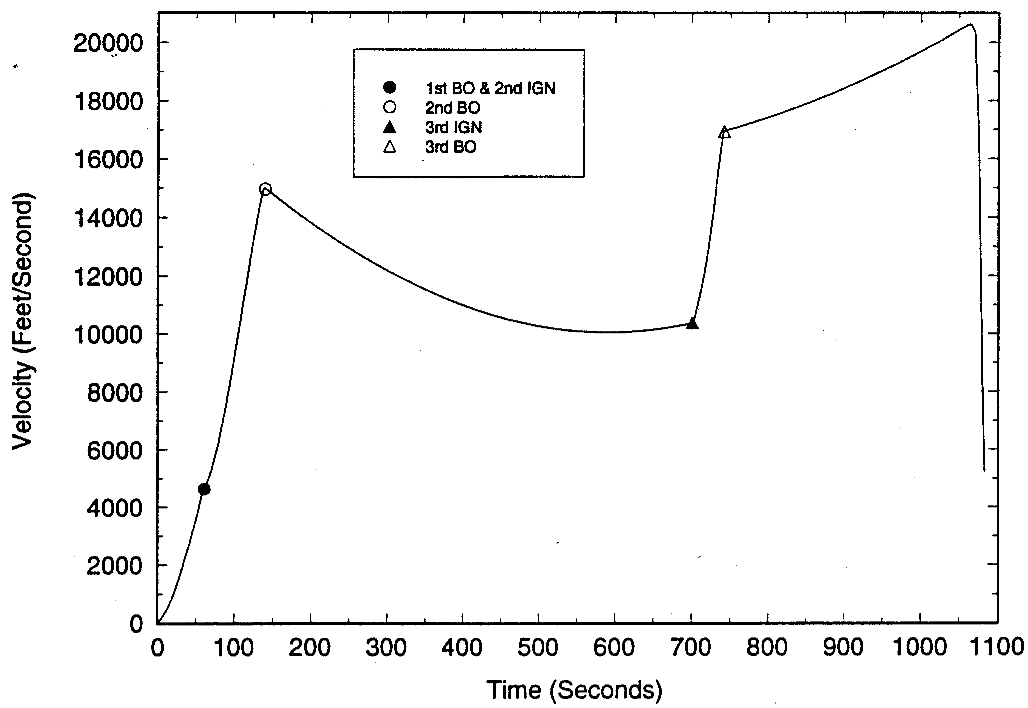

Figure 2.2-4 Velocity versus Time for a STARS I Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

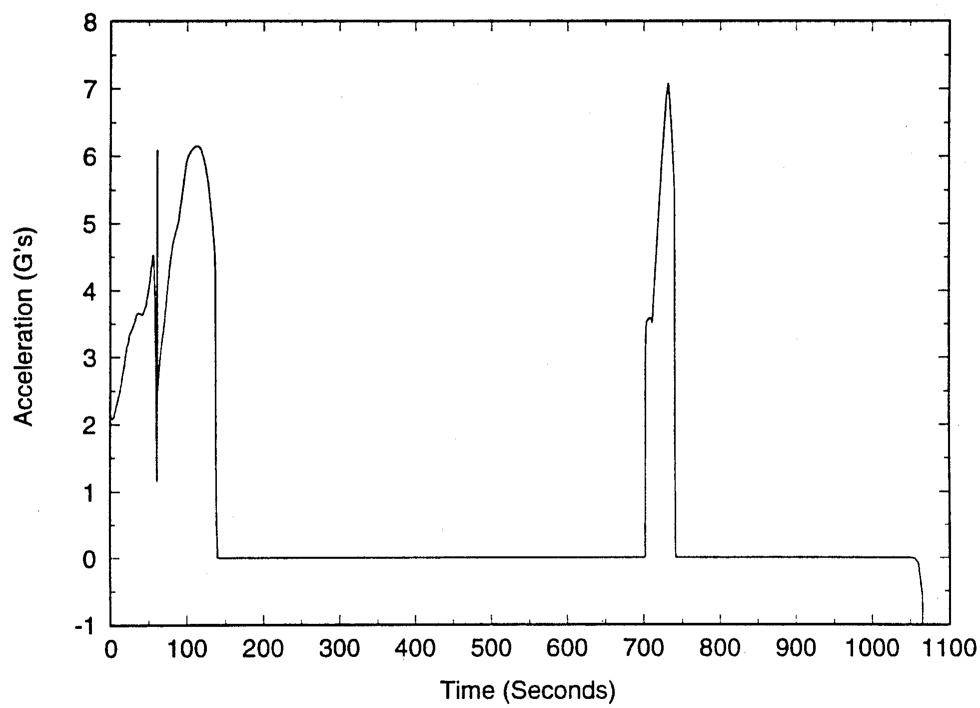

Figure 2.2-5 Acceleration versus Time for a STARS I Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

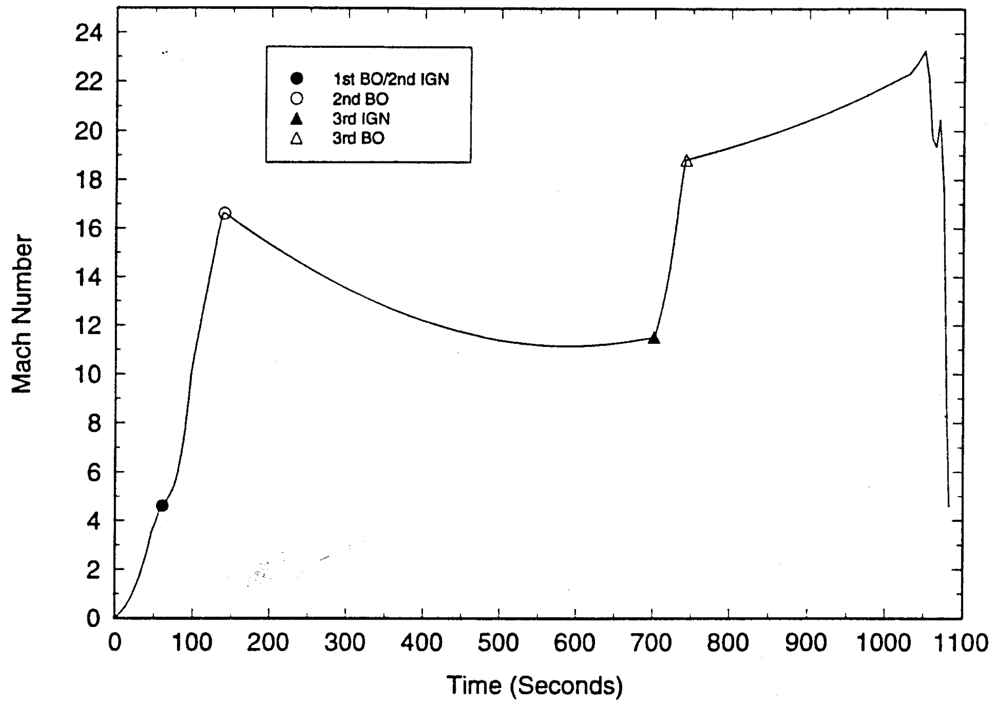

Figure 2.2-6 Mach Number versus Time for a STARS I Carrying a 300 lb Payload with SKU = 40 (Mission Type I)

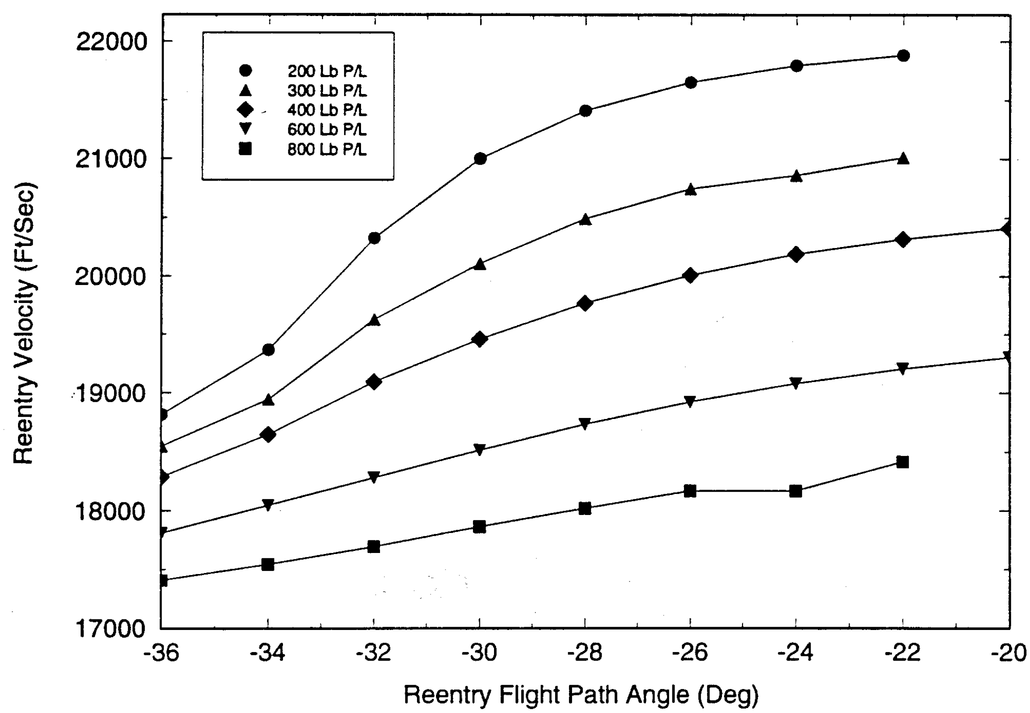

Figure 2.2-7 Reentry Velocity versus Flight Path Angle and Payload Weight for SKU = 0 (Mission Type I)

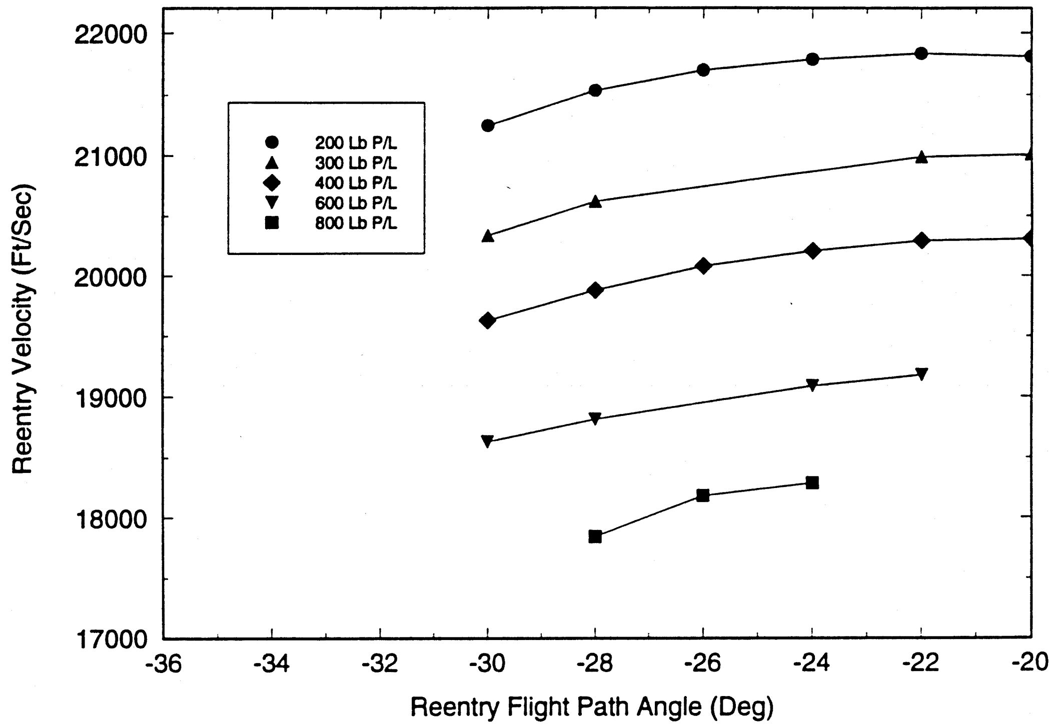

Figure 2.2-8 Reentry Velocity versus Flight Path Angle and Payload Weight for SKU = 20 (Mission Type I)

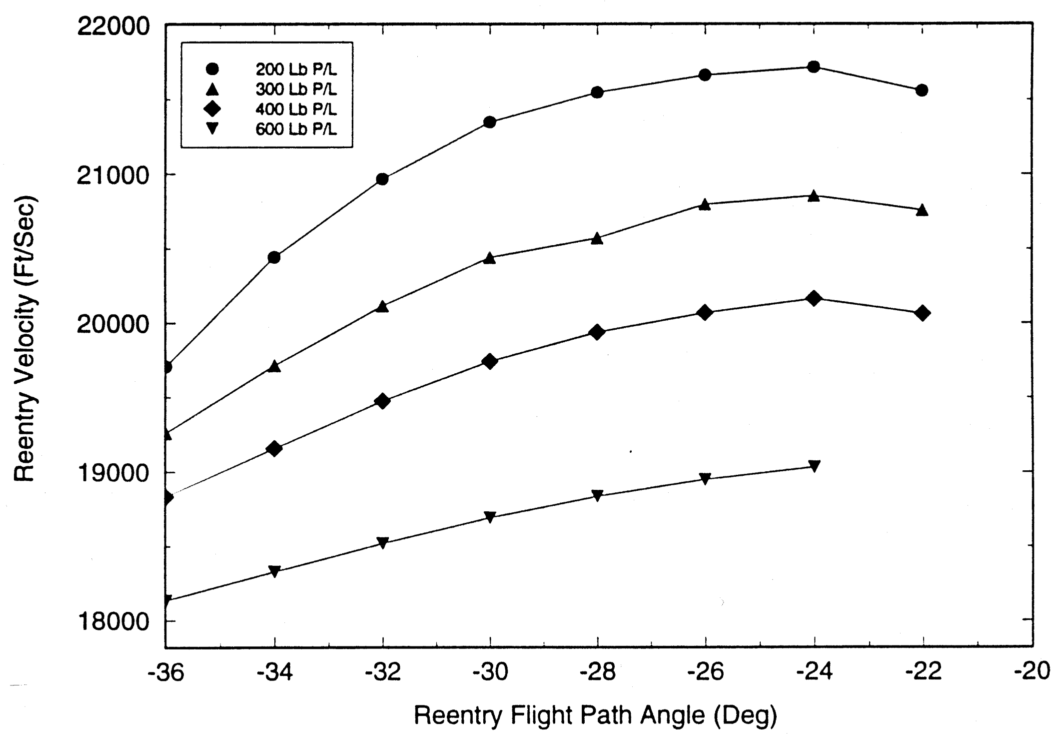

Figure 2.2-9 Reentry Velocity versus Flight Path Angle and Payload Weight for SKU = 40 (Mission Type I)

2.2.2 Altitude Requirement with Subsequent Reentry Experiment (Mission Type II)

For a mission of this type, some compromise must be made in the reentry conditions that were shown to be achievable for the Type I mission. The type of flight profile that would be flown in this case would allow for the payload to fly in close proximity to a satellite or to be at the proper elevation angle with respect to a ground based observer during some part of its exoatmospheric flight. The assumptions that were made previously also apply to this mission. The TSAP trajectory optimizer program was allowed to maximize the altitude while reentering at the same target coordinates as in the Type I mission. Specifically, reentry (300 Kft) was set to occur at a longitude of 169.0° E and a latitude of 11.5° N. To achieve maximum altitude, the third stage Orbus 1 motor must be ignited as soon as possible after second stage burnout. The simulations that have been run for inclusion in this section of the handbook allowed 60 seconds of coast between second stage burnout and third stage ignition.

The flight performance data are shown in Figures 2.2-10 through 2.2-13. The data are shown for an SKU parameter of 50, and a payload weight of 300 lb. The variation of altitude with time and ground range is shown in Figures 2.2-10 and 2.2-11, respectively. The ground track and the IIP for a ballistic coefficient of 400 lb/ft^2 are shown in Figure 2.2-12. The velocity profile is plotted as a function of time in Figure 2.2-13. Summary results for a series of trajectory simulations made for payload weights of 200 through 1000 lb for this type of mission are shown in Figures 2.2-14 through 2.2-16. The maximum altitude achieved is plotted as a function of payload weight and SKU number in Figure 2.2-14. The variations of reentry velocity (the reentry interface is assumed to occur at 300,000 ft) and flight path angle with payload weight and SKU are shown in Figures 2.2-15 and 2.2-16, respectively.

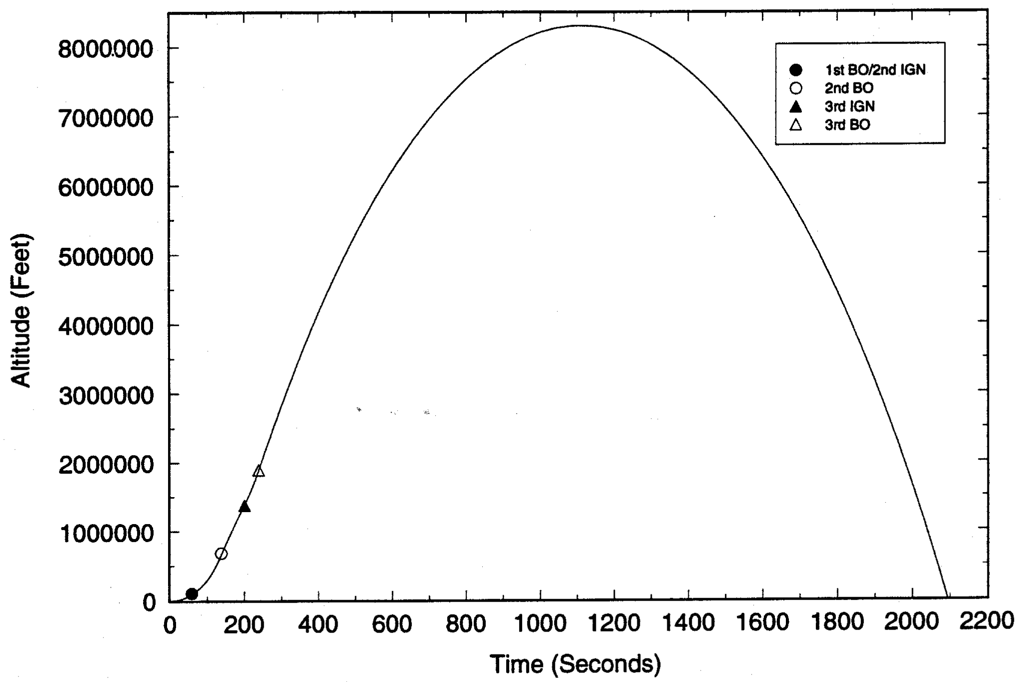

Figure 2.2-10 Altitude versus Time for a STARS I Carrying a 300 lb Payload with SKU = 50 (Mission Type II)

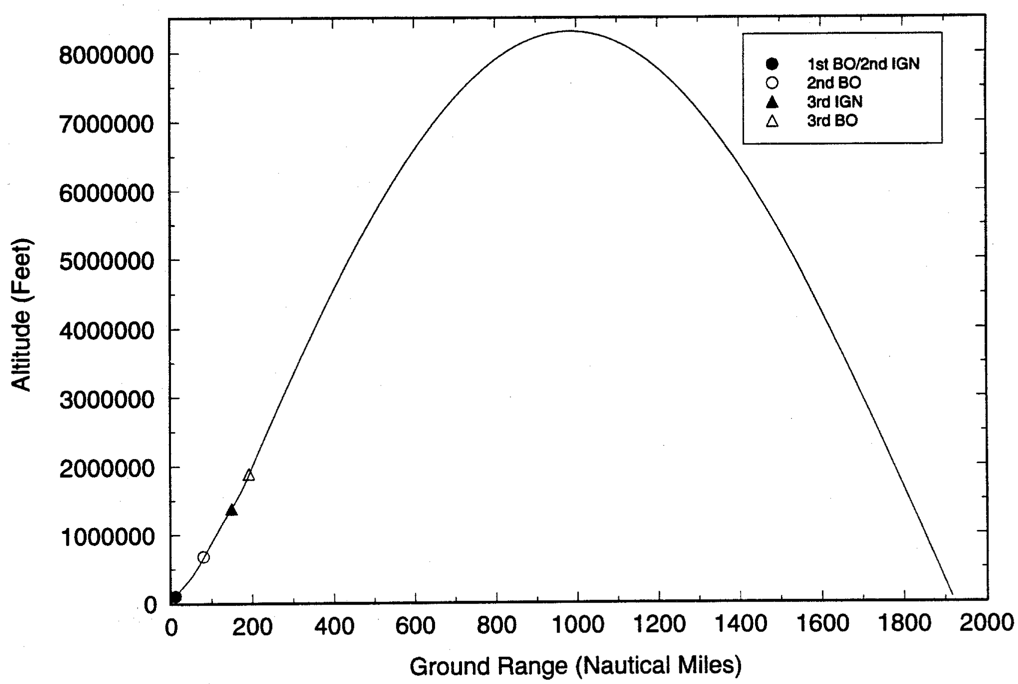

Figure 2.2-11 Altitude versus Ground Range for a STARS I Carrying a 300 lb Payload with SKU = 50 (Mission Type II)

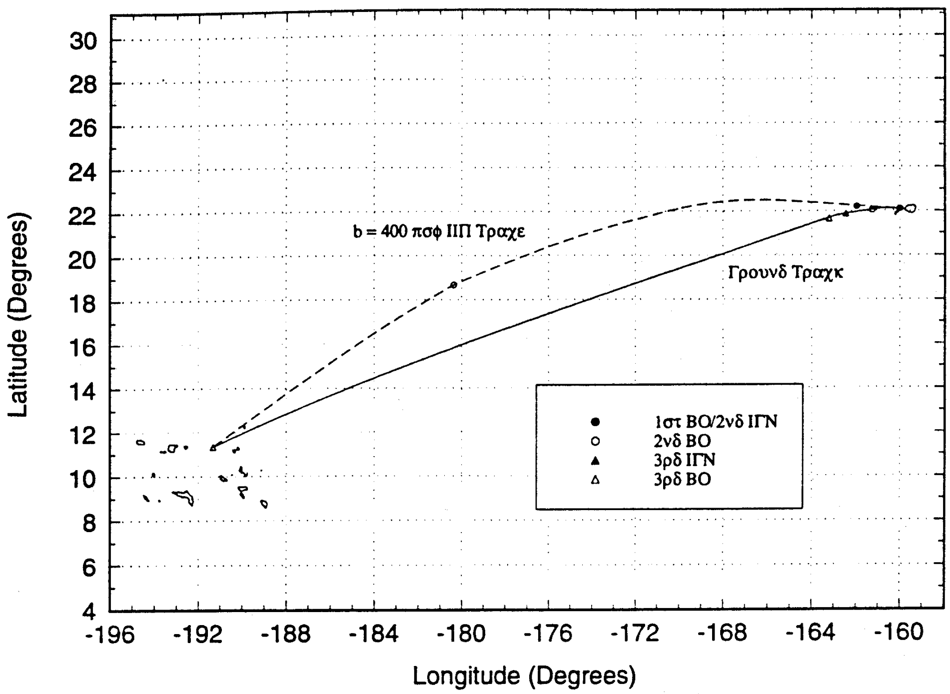

Figure 2.2-12 Ground Track for a STARS I Carrying a 300 lb Payload with SKU = 50 (Mission Type II)

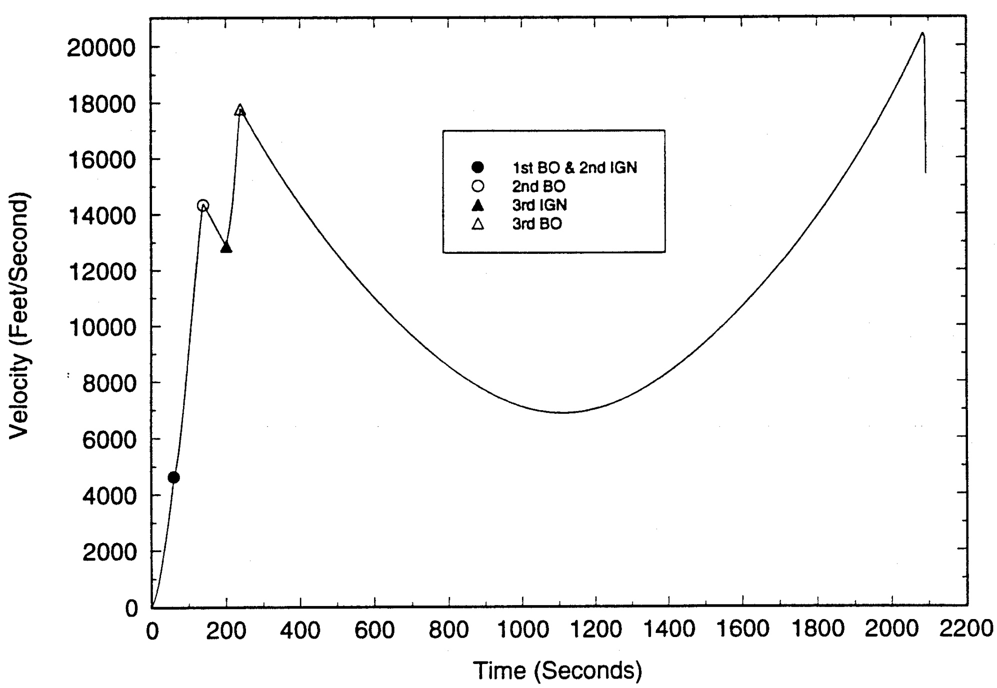

Figure 2.2-13 Velocity versus Time for a STARS I Carrying a 300 lb Payload with SKU = 50 (Mission Type II)

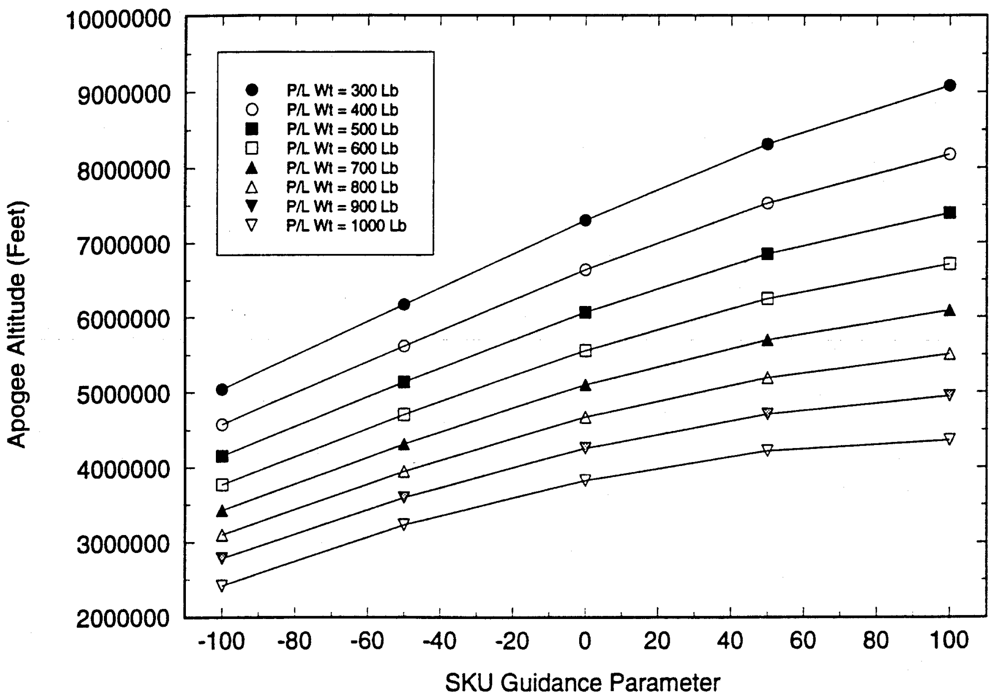

Figure 2.2-14 Apogee Altitude for a STARS I Mission Type II as a Function of SKU Parameter and Payload Weight

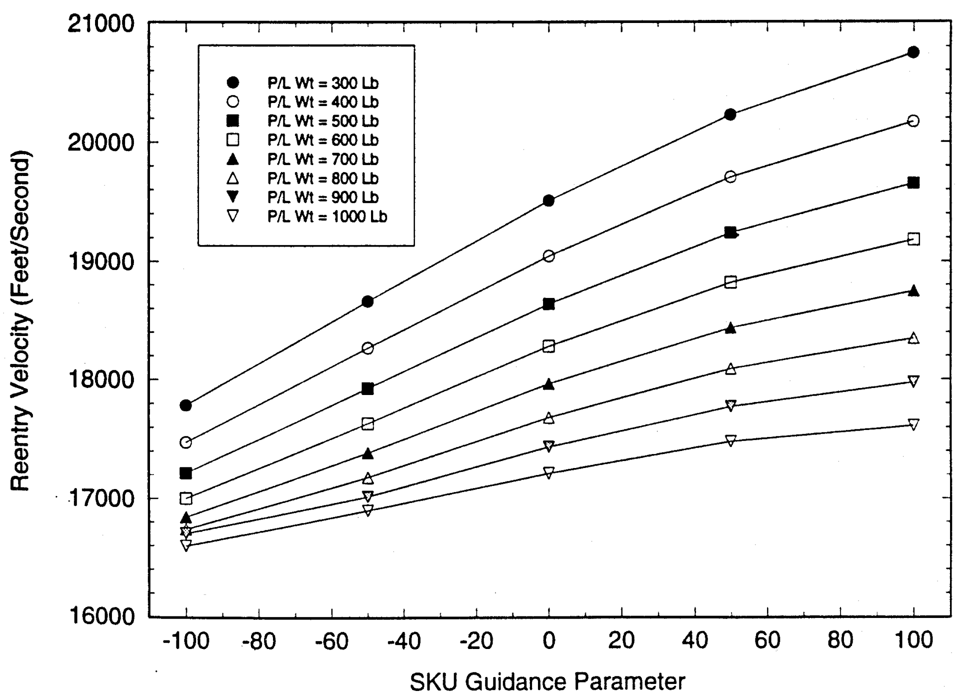

Figure 2.2-15 Reentry Velocity for a STARS I Mission Type II as a Function of SKU Parameter and Payload Weight

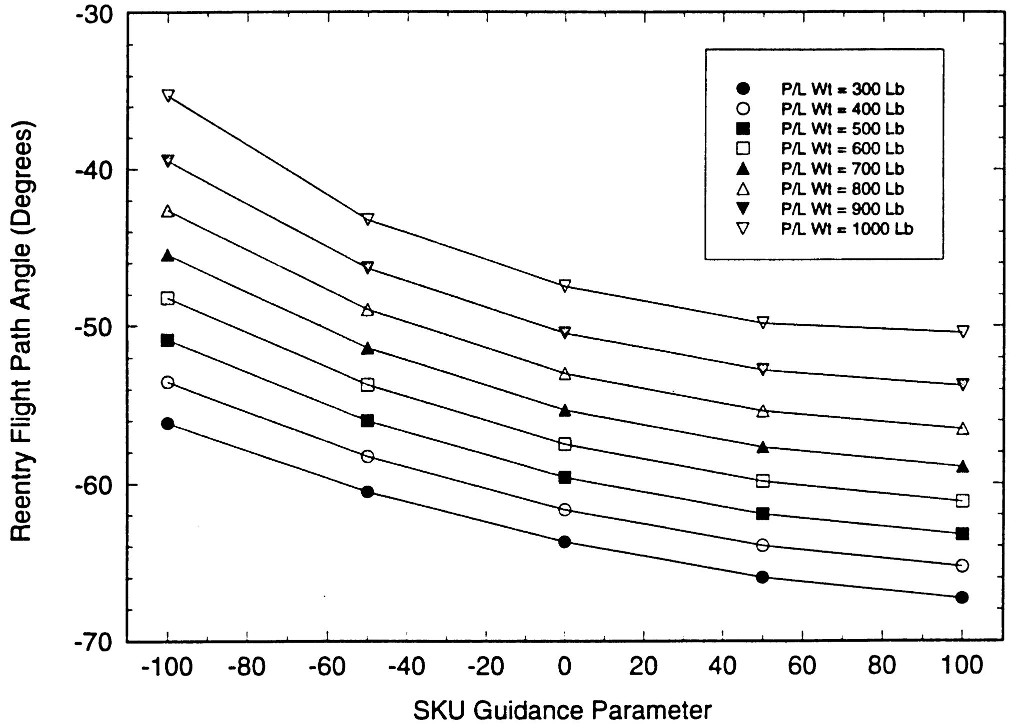

Figure 2.2-16 Reentry Flight Path Angle for a STARS I Mission Type II as a Function of SKU Parameter and Payload Weight

2.2.3 Experiment Carrier Vehicle (Mission Type III)

This type of mission uses a modified STARS I as a sounding rocket type vehicle to carry scientific payloads to high altitudes. This experiment could be executed to place a payload at extremely high altitudes and/or achieve many minutes of time in a microgravity environment. A Type III mission would be the simplest of the types of missions that might be flown with the STARS vehicle. It would be launched from KTF on a flight azimuth to the northwest with a stipulation that all stages land in a cleared area. As in the Type II mission, the third stage would be fired as soon as possible after second stage burnout. Following burnout, the third stage would be separated and the ACS system could be activated to do any experiment related payload pointing. Payload recovery using an over water recovery system could also be accomplished if required, although the impact ranges from the launch site would be large.

Simulations have been made for a range of payload weights from 1000 to 4000 lb. The following assumptions were made in completing the simulations:

1. A SKU parameter of 100 was used since a highly lofted trajectory would be the best for this type of mission.
2. Sixty seconds of coast time was allowed between second stage burnout and third stage ignition.

The variation of altitude with time and range is shown in Figures 2.2-17 and 2.2-18 for a 1000 lb payload and an SKU parameter of 100. The ground track is shown in Figure 2.2-19. In this case, the plot of the IIP overlies the ground track plot. The variation of velocity with time is shown in Figure 2.2-20. The predicted apogee altitude is plotted as a function of payload weight in 2.2-21. The available data taking time, which is measured from Orbus 1 burnout to re-entry at 300 Kft on the trajectory downleg is also shown as a function of payload weight in Figure 2.2-21.

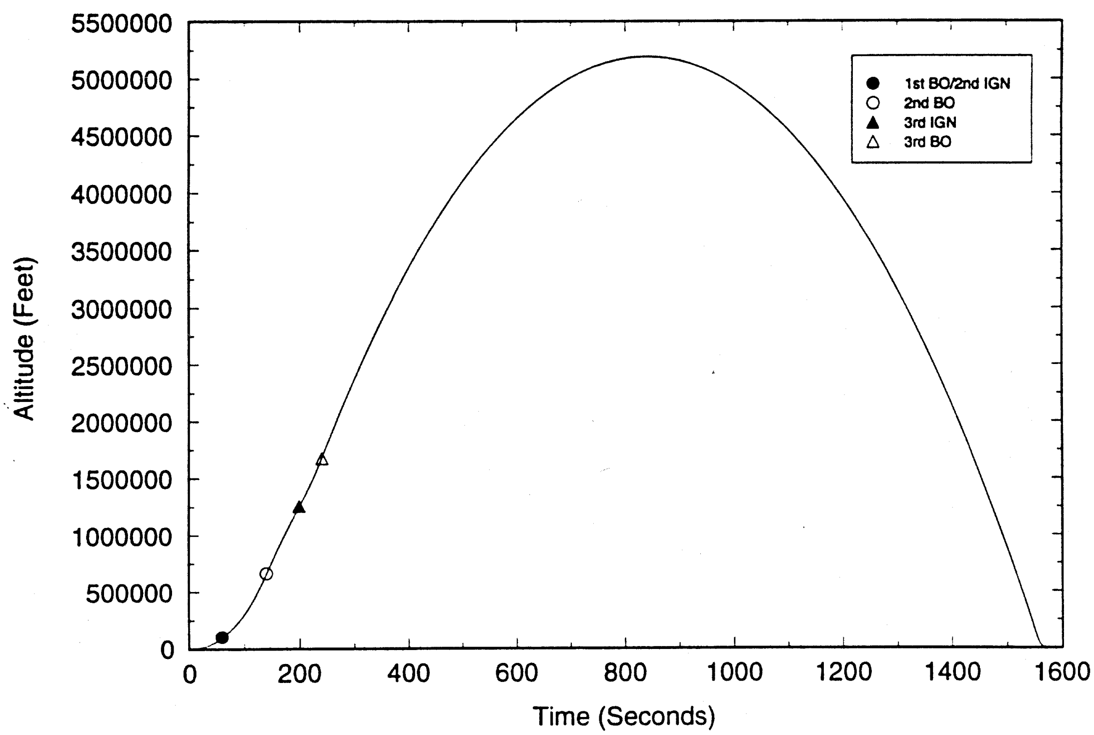

Figure 2.2-17 Altitude versus Time for a STARS I Vehicle Carrying a 1000 lb Payload with SKU = 100 (Mission Type III)

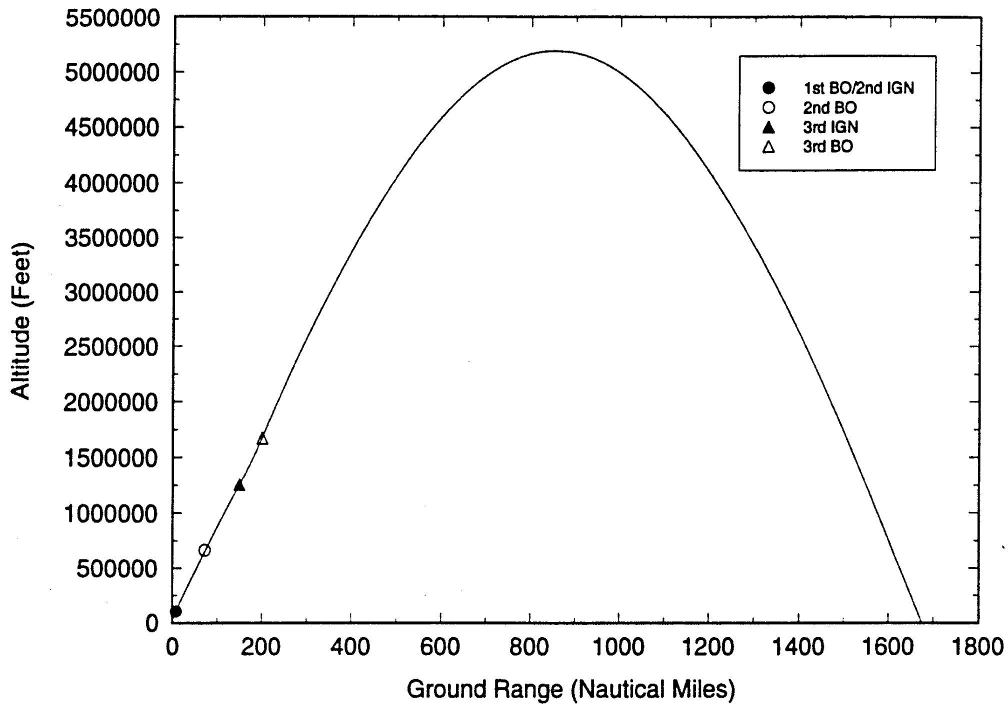

Figure 2.2-18 Altitude versus Ground Range for STARS I Carrying a 1000 lb Payload with SKU = 100 (Mission Type III)

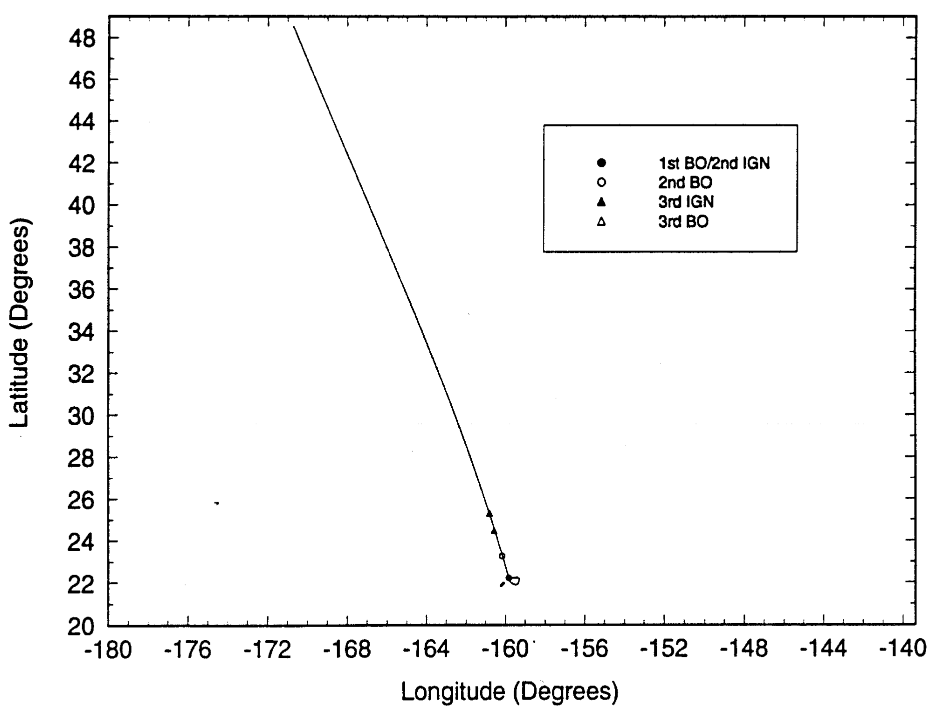

Figure 2.2-19 Ground Track for a STARS I Carrying a 1000 lb Payload with SKU = 100 (Mission Type III)

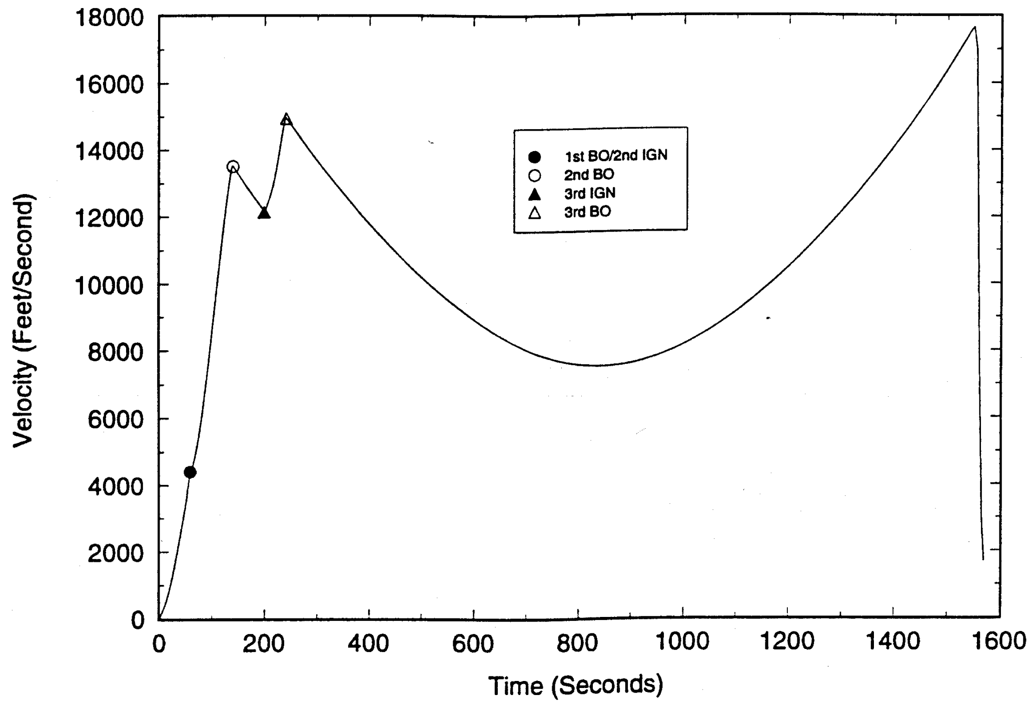

Figure 2.2-20 Velocity versus Time for a STARS I Carrying a 1000 lb Payload with SKU = 100 (Mission Type III)

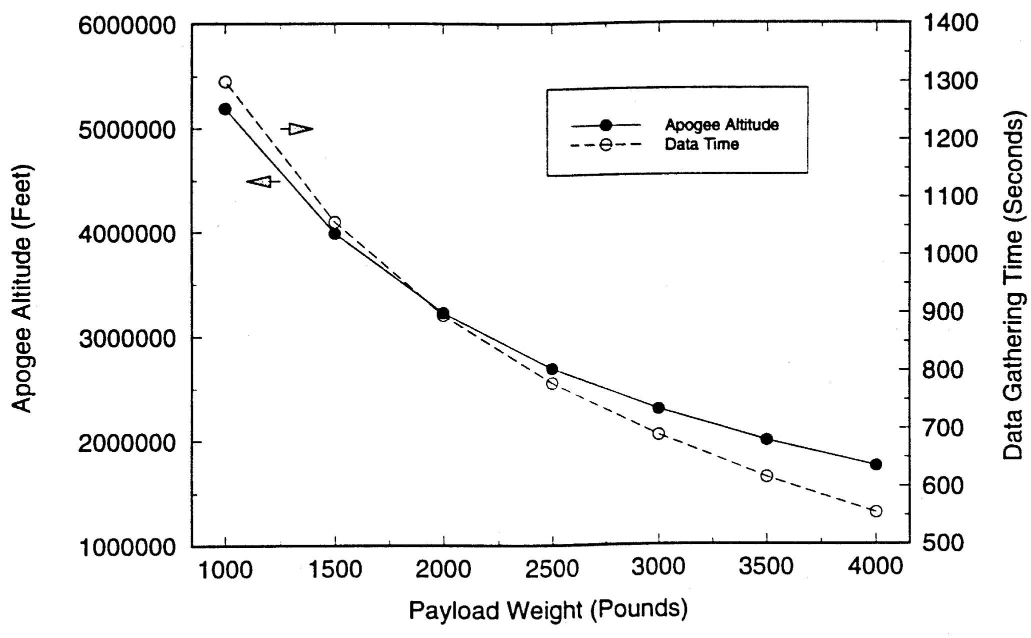

Figure 2.2-21 Apogee Altitude and Experiment Time for a STARS I Carrying a 1000 lb Payload with SKU = 100 (Mission Type III)

2.3 MISSION ACCURACY

The mission data presented in Subsection 2.2 represent the expected performance for a nominal missile system. While every effort will be made to control and understand those factors contributing to vehicle off nominal flight performance, there are some factors whose effects can not be ascertained until they manifest themselves in flight. This subsection presents an overview of some contributing factors affecting the STARS flight performance, and are presented to aid the experimenter in the mission planning process.

2.3.1 Mission Design Parameters

Nominal booster performance is affected by mission design parameters such as the payload weight, the fly-out azimuth from KTF, the SKU guidance parameter, the time and size of the Niihau dogleg, the rate limitations imposed during the dogleg turn, the third stage ignition time, and the extent of the third stage dogleg turn. Each parameter can be adjusted to accommodate the mission requirements within the bounds of the allowable range safety constraints and missile capabilities.

Off nominal missile performance occurs primarily due to uncertainties in the apriori knowledge of such factors as vehicle weights, consumables usage, and delivered total impulse of the rocket motors. The STARS I is targeted to intercept a position in space or on the surface of the earth. A positional constraint is required to ensure the third stage and the payload(s) will impact in safe areas, as well as, insuring the downrange instrumentation will acquire the payload(s) and retrieve data. Positional accuracy is affected by such factors as navigation system errors, and the uncertainty in third stage weight and total impulse delivered. Target miss distance due to motor performance uncertainty is generally aligned along track, while navigation errors are primarily in the cross-range direction.

Miss distance data for two Type I flights targeted to locations in the vicinity of KMR are summarized in Tables 2.3-1 and 2.3-2. The miss distances resulting from the primary contributors to dispersion during each stage are summarized in the tables. The data in Table 2.3-1 is representative of a flight having a variable third stage ignition time. Ignition time is varied to reduce the time of flight dispersions and to allow increased weight to be flown to the target. The data in Table 2.3-2 represent the dispersion data for a fixed third stage ignition time. A fixed ignition time produces a simpler and more consistent sequencing of events. However, these result in larger time of flight dispersions and the delivery of less than the maximum weight possible to the target for a given ignition time.

The target miss data in Tables 2.3-1 and 2.3-2 assume the missile navigator is perfect. Covariance analysis data for the MAPS IMU for the mission of Table 2.3-2 are shown in Figures 2.3-1 through 2.3-3. These data are representative for most missions flown using the STARS vehicle. The ellipse sizes are exaggerated to show the cross-range alignment of the navigation error. Figure 2.3-4 shows the 1-sigma navigation error for altitude, latitude,and longitude. These errors cannot be eliminated by the missile guidance sytem, and contribute to the overall target miss distance. The addition of the GPS to update the IMU will essentially eliminate most of the uncertainty in the navigated state position.

Table 2.3-1 Variable Third Stage Ignition Time Three Sigma Dispersion Summary

Contributor	Delta in 3rd Stage Ign (Sec)	Delta in Time at Target (Sec)	Latitude Miss (NM)	Longitude Miss (NM)	Delta Velocity (Ft/Sec)	Delta Flt Path Angle (Deg)
Specific Impulse						
1st Stage (+0.804%)	+7	-1.01	+0.02	-0.15	+77.76	+0.08
1st Stage (-0.804%)	-9	+0.29	-0.03	-0.09	-67.15	-0.09
2nd Stage (+1.395%)	+21	-1.30	+0.06	-0.03	+207.49	+0.19
2nd Stage (-1.395%)	-25	+0.21	-0.08	+0.09	-174.94	-0.27
3rd Stage (+0.500%)	0	+0.56	+1.82	+2.55	+19.55	+0.06
3rd Stage (-0.500%)	0	-0.29	-1.84	-2.61	-26.87	-0.18
Thrust						
1st Stage (+6.3%)	+14	-2.98	+0.05	-0.03	+110.66	+0.13
1st Stage (-6.3%)	-23	+1.18	-0.06	+0.09	-107.34	-0.17
2nd Stage (+9.0%)	0	+1.46	-0.01	-0.09	+25.84	+0.02
2nd Stage (-9.0%)	-3	-0.94	-0.03	-0.09	-52.53	-0.06
3rd Stage (+6.3%)	0	-0.58	+0.07	+0.03	-14.58	-0.02
3rd Stage (-6.3%)	0	+0.89	-0.07	-0.15	+7.04	0.00
Propellant Weight						
1st Stage (+100.5 lb)	+3	-0.41	-0.02	-0.09	+32.40	+0.04
1st Stage (-100.5 lb)	-4	+0.12	-0.02	-0.09	-30.10	-0.05
2nd Stage (+39.3 lb)	+2	-0.33	-0.01	-0.09	+26.09	+0.03
2nd Stage (-39.3 lb)	-3	+0.06	-0.01	-0.03	-24.09	-0.04
3rd Stage (+4.5 lb)	+1	-0.69	-1.38	-2.01	+0.65	-0.02
3rd Stage (-4.5 lb)	-1	+0.98	+1.40	+1.89	-8.80	+0.01
Fixed Inert Weight						
1st Stage (+60.3 lb)	-2	+0.55	+0.01	-0.09	-29.16	-0.04
1st Stage (-60.3 lb)	+2	-0.29	-0.01	-0.09	+22.38	+0.03
2nd Stage (+18.6 lb)	-6	+0.27	+0.01	-0.03	-50.86	-0.07
2nd Stage (-18.6 lb)	+5	-0.56	+0.02	-0.09	+54.01	+0.06
3rd Stage (+8.4 lb)	-3	-0.41	-1.98	-2.79	-47.50	-0.11
3rd Stage (-8.4 lb)	+2	+0.15	+1.94	+2.67	+49.35	+0.10
Expendable Inert Weight						
1st Stage (+75 lb)	+1	-0.34	+0.01	-0.03	+17.25	+0.02
1st Stage (-75 lb)	-1	+0.60	+0.01	-0.03	-24.07	-0.04
2nd Stage (+40 lb)	+5	-0.93	-0.02	-0.09	+66.80	+0.07
2nd Stage (-40 lb)	-7	+0.13	-0.01	-0.03	-54.84	-0.08
3rd Stage (+3 lb)	0	+0.13	+0.39	+0.51	+4.41	+0.02
3rd Stage (-3 lb)	0	-0.12	-0.02	-0.63	-4.35	-0.01
Second Stage TVC Fluid Usage						
2nd Stage (+4.5 gal)	+13	-0.93	+0.05	-0.03	+110.66	+0.13
2nd Stage (-4.5 gal)	-11	-0.12	-0.06	+0.09	-107.34	-0.17
Total RSS +3s Variation	+30.5	+2.54	+3.03	+4.18	+295.05	+0.32
Total RSS -3s Variation	-38.6	-4.01	-3.04	-4.37	-269.65	-0.45

Table 2.3-2 Fixed Third Stage Ignition Time Three Sigma Dispersion Summary

Contributor	Delta in 3rd Stage Ign (Sec)	Delta in Time at Target (Sec)	Latitude Miss (NM)	Longitude Miss (NM)	Delta Velocity (Ft/Sec)	Delta Flt Path Angle (Deg)
Specific Impulse						
1st Stage (+0.804%)	0	-2.59	+0.15	-0.04	+87.58	-0.03
1st Stage (-0.804%)	0	+3.10	+0.12	-0.04	-104.18	-0.01
2nd Stage (+1.395%)	0	-6.54	+0.16	-0.07	+239.04	-0.01
2nd Stage (-1.395%)	0	+8.48	+0.09	0.00	-293.06	-0.05
3rd Stage (+0.500%)	0	+0.37	+2.23	+1.96	+21.40	+0.06
3rd Stage (-0.500%)	0	-0.36	-1.94	-2.00	-21.47	-0.06
Thrust						
1st Stage (+6.3%)	0	-6.53	+0.17	-0.04	+144.05	-0.04
1st Stage (-6.3%)	0	+8.80	+0.09	-0.04	-210.40	-0.02
2nd Stage (+9.0%)	0	-0.65	+0.13	-0.04	-41.17	+0.01
2nd Stage (-9.0%)	0	+1.83	+0.12	-0.04	+11.63	-0.01
3rd Stage (+6.3%)	0	-0.34	+0.05	-0.14	-2.97	-0.02
3rd Stage (-6.3%)	0	+0.63	+0.24	+0.07	-5.36	0.00
Propellant Weight						
1st Stage (+100.5 lb)	0	-1.10	+0.14	-0.04	+32.40	+0.04
1st Stage (-100.5 lb)	0	+1.15	+0.12	-0.04	-30.10	-0.05
2nd Stage (+39.3 lb)	0	-0.74	+0.13	-0.04	+27.53	-0.01
2nd Stage (-39.3 lb)	0	+0.78	+0.13	-0.04	-28.82	0.00
3rd Stage (+4.5 lb)	0	+0.76	+1.69	+1.44	-1.46	+0.05
3rd Stage (-4.5 lb)	0	-0.72	-1.40	-1.48	+0.55	-0.05
Fixed Inert Weight						
1st Stage (+60.3 lb)	0	+0.78	+0.13	-0.04	-26.54	0.00
1st Stage (-60.3 lb)	0	-0.75	+0.14	-0.04	+25.59	-0.01
2nd Stage (+18.6 lb)	0	+2.20	+0.12	-0.04	-78.02	-0.01
2nd Stage (-18.6 lb)	0	-1.81	+0.14	-0.04	+64.72	-0.02
3rd Stage (+8.4 lb)	0	+0.45	-2.38	-2.44	-57.95	-0.07
3rd Stage (-8.4 lb)	0	-0.43	+2.65	+2.34	+57.01	+0.06
Expendable Inert Weight						
1st Stage (+75 lb)	0	-0.48	+0.14	-0.04	+16.47	0.00
1st Stage (-75 lb)	0	+0.50	+0.13	-0.04	-17.21	0.00
2nd Stage (+40 lb)	0	-2.04	+0.14	-0.07	+74.40	-0.02
2nd Stage (-40 lb)	0	+2.45	+0.12	-0.04	-87.72	-0.01
3rd Stage (+3 lb)	0	+0.10	+0.67	+0.48	+5.62	+0.01
3rd Stage (-3 lb)	0	-0.09	-0.40	-0.55	-5.55	-0.02
Second Stage TVC Fluid Usage						
2nd Stage (+4.5 gal)	0	-4.55	+0.17	-0.04	+167.87	-0.05
2nd Stage (-4.5 gal)	0	+3.68	+0.11	-0.04	-131.09	-0.01
Total RSS +3s Variation	0	+13.81	+3.95	+3.41	+360.66	+0.11
Total RSS -3s Variation	0	-11.14	-3.40	-3.53	-424.58	-0.15

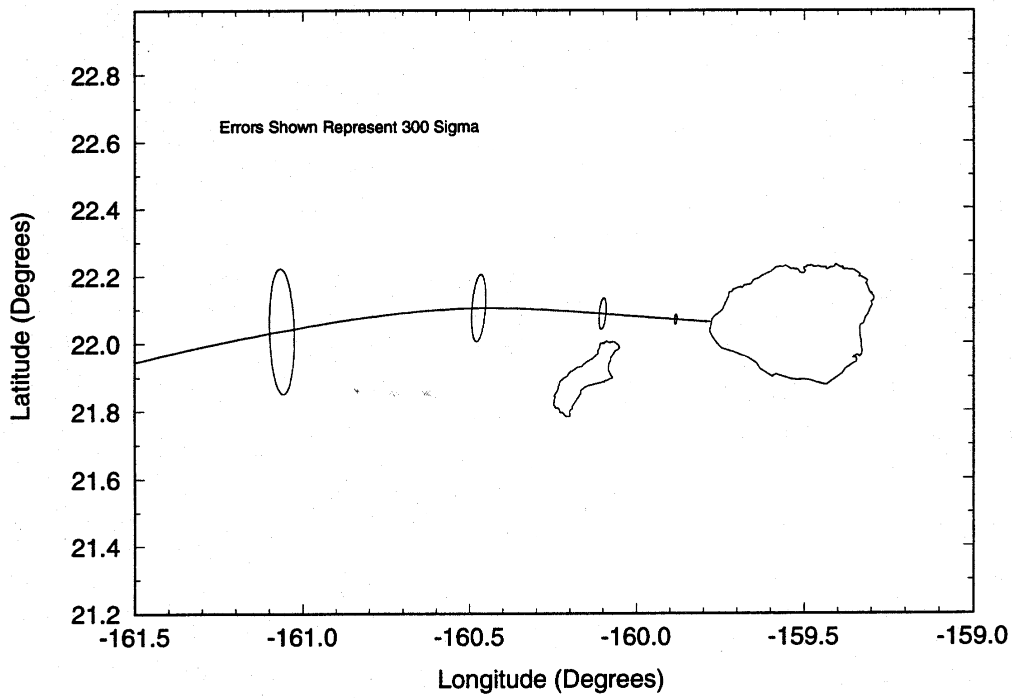

Figure 2.3-1 STARS I Navigator Error During First and Second Stage Boost with Sigma = 300

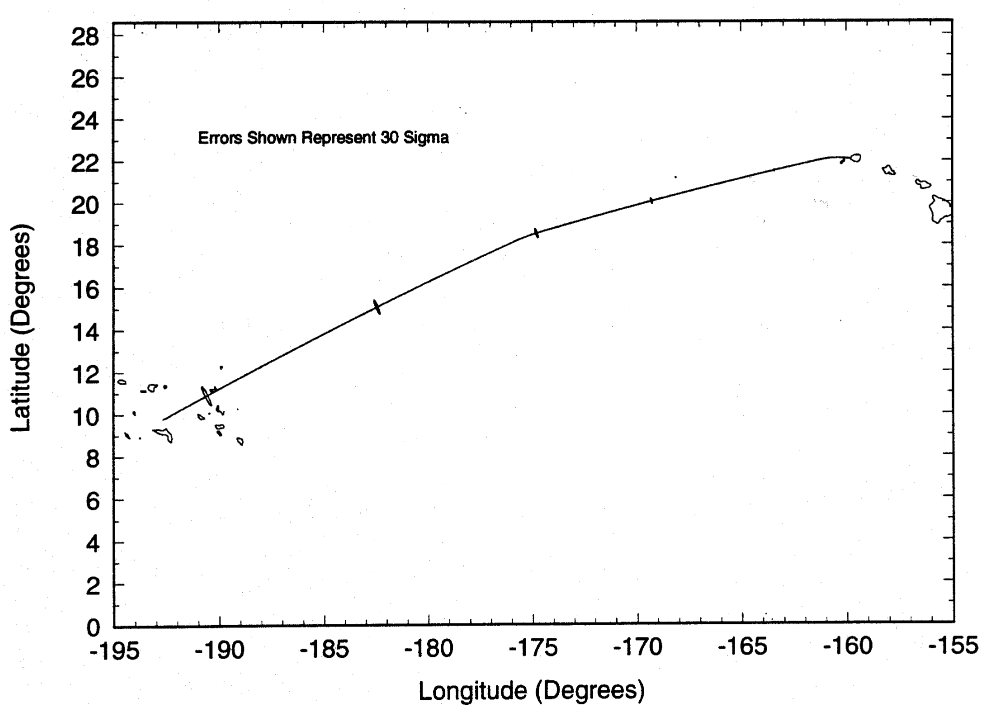

Figure 2.3-2 STARS I Navigator Error for the Entire Mission with Sigma = 30

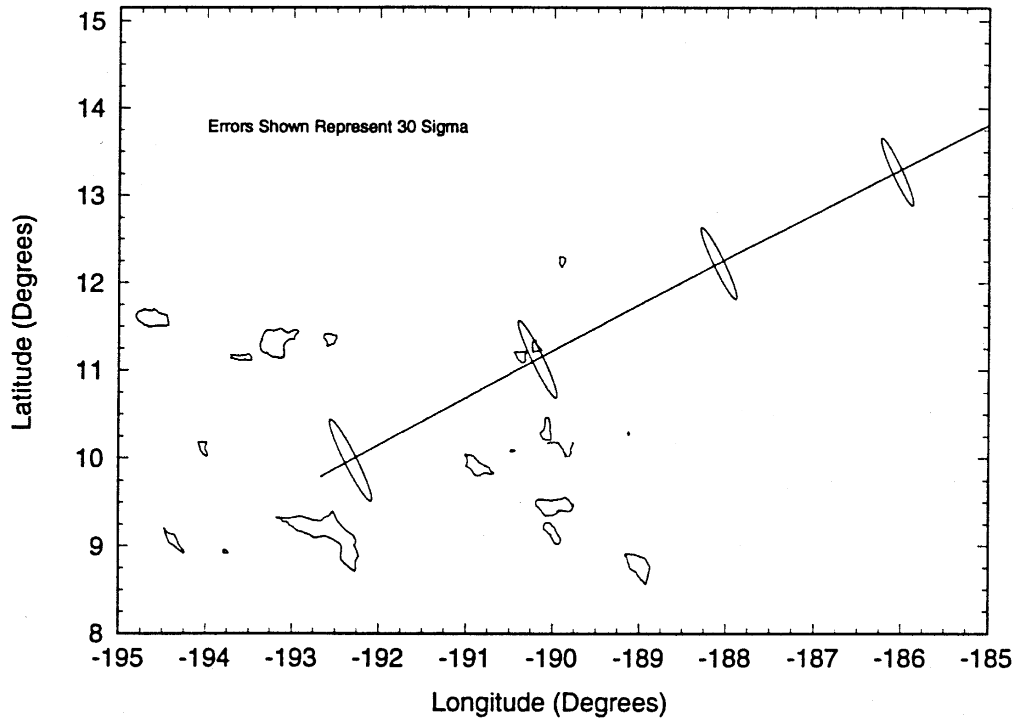

Figure 2.3-3 STARS I Navigator Error During the Terminal Portion of the Mission with Sigma = 30

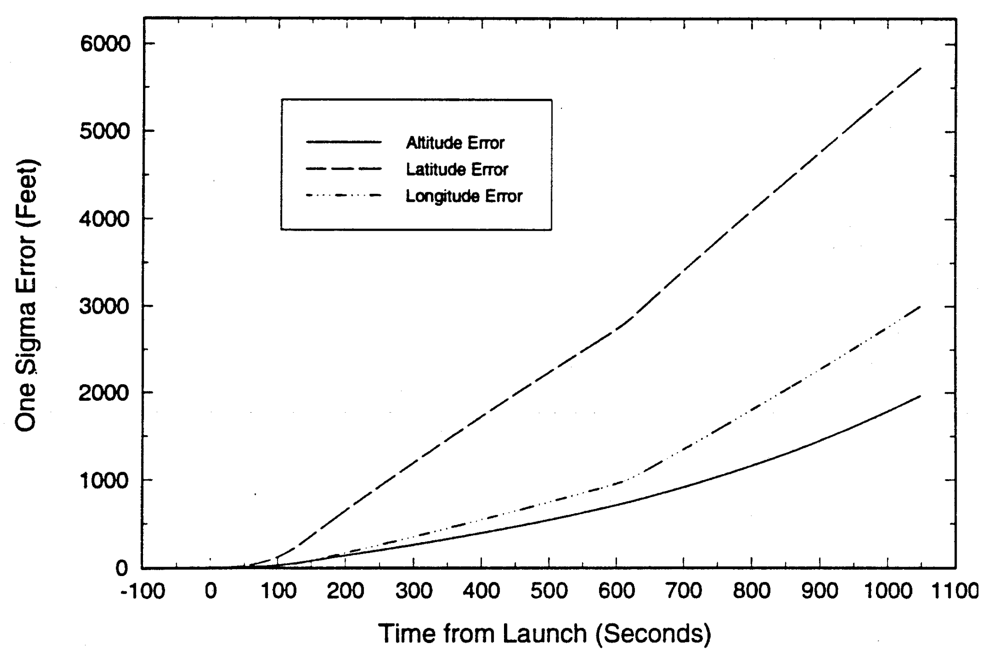

Figure 2.3-4 STARS I One Sigma Navigator Position Error as a Function of Mission Time

2.3.2 Mission Planning Philosophy

Since nominal rocket motor performance data and weights are provided, there is a tendency to use this data for mission planning studies. When used in mission planning studies to determine the limits of booster performance, the use of nominal data can pose difficulties as planning for the mission proceeds. For example, if the nominal motor performance is used to define the maximum weight delivered to a given target point, this payload weight can, in reality, be delivered to the specified point only if nominal or greater total impulse is delivered. Since an under performing motor is equally likely, the desired test conditions will be obtained only half the time. This situation is accommodated during the mission design process using performance data that approximates a 3-sigma low performing booster to ensure that the desired target conditions are attainable in all but the most statistically unlikely situations. The nominal performance data can then be used with this payload weight to demonstrate the expected performance at target.

2.4 ATTITUDE CONTROL SYSTEM

The STARS I missile utilizes a cold gas (nitrogen) ACS for exoatmospheric control of the body attitude. The system is activated during a mission to reorient the third stage after second stage separation and prior to the nose shroud ejection, to reorient to the third stage initial burn attitude, to remove attitude errors and rates due to disturbing torques (i.e. stage separations, payload separations, and retro motor firings), and to provide roll attitude control during the Orbus 1 burn. The STARS I ACS also is capable of modifying the third stage structure velocity to provide increased separation between the payload(s) and the spent third stage during reentry.

The ACS utilizes refurbished hardware from the Pershing II missile, including the solenoid valves, manifold, pressure regulator, and high pressure nitrogen tank. The Pershing roll nozzle assemblies are used after being modified to incorporate a properly sized nozzle orifice to meet the mission specific requirements. The Pershing II solenoid valves provide approximately two pounds of thrust in a vacuum. The pressure vessel has a volume of 780 in^3. The system is typically operated at a pressure of 3600 to 4000 psi. To achieve a pressure of 3600 psi, 7.8 lbm of nitrogen are required.

Parametric nozzle testing has been performed with the nozzle assemblies, manifold/regulator, and the STARS I nozzle blocks in a vacuum. The variations of nozzle thrust with orifice diameter were measured during the test at regulated pressures of 200 and 300 psi. These data, which are shown in Figure 2.4-1, provides the necessary information to size the nozzle orifices for each mission.

An additional option exists to run the ACS with an unregulated pressure supply. An unregulated system can provide high thrust and a quick maneuvering capability. Tests show the thrusters can provide up to 60 pounds of thrust in a vacuum at 3600 psi.

The ACS is utilized during the third stage flight in the presence of widely varying mass properties. The variation in mass properties coupled with the fixed nozzle orifices and the regulated ACS pressure causes the ACS to demonstrate widely varying performance (i.e. highest body rates during controlled maneuvering). Immediately following second stage separation, the system is relatively sluggish; however, after the third stage retro motors have fired, the ACS exhibits the highest control responsiveness achieved during the flight. The deadband control exhibits an opposite behavior. It is greatest when the ACS is first activated, then deteriorates, and is the least at the time of the third stage retro fire.

Within the allowable engineering constraints, the STARS ACS can be tailored to satisfy the mission requirements for each mission. For example, for a mission requiring additional maneuvers, more nitrogen gas can be carried by adding additional pressure tanks. Requests for additional ACS capability should be made by the payload designers early in the mission planning phase.

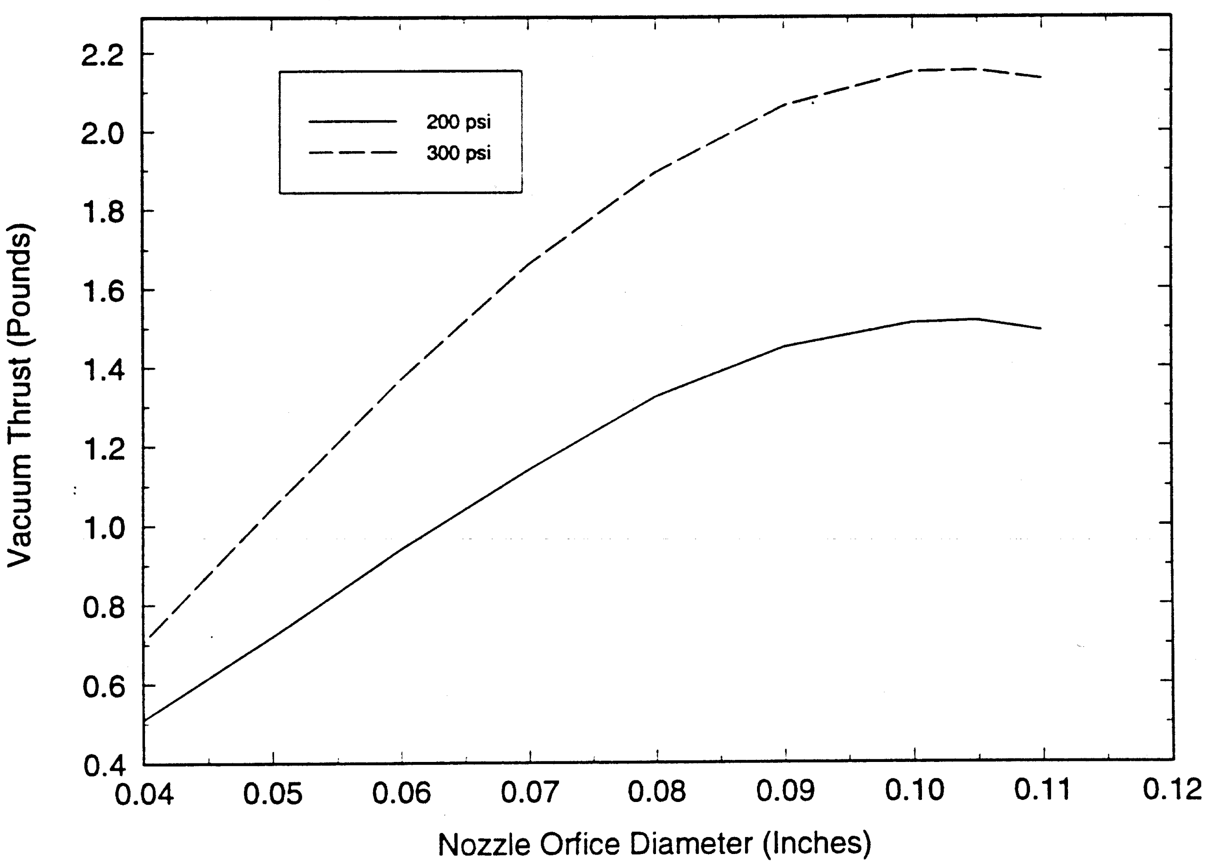

Figure 2.4-1 Thrust versus ACS Nozzle Orifice Diameter at Regulated Pressures of 200 and 300 psi

2.5 RV/LAUNCH VEHICLE SEPARATION

The STARS I system is designed to provide a flexible platform for satisfying the payload experiment objectives. The experimenter's requirements are an integral part of the mission planning process, and will usually result in flight software and sequencing that is specific to the payloads and the mission being flown.

Most of the payload activities occur after third stage burnout. Typically, a payload is separated from the spent third stage after a short coast period and an ACS reorientation maneuver to correctly position the payload to the proper orientation prior to release (e.g. to achieve 0° angle of attack at reentry). For the release of multiple payloads, a small separation delta velocity can be imparted with the ACS after the release of each payload. With adequate separation ensured, an additional ACS reorientation maneuver can be performed prior to the next payload release. Once all of the payloads have been released, a reorientation of the third stage can be performed prior to the ignition of the retro motors.

Usually, a positional separation requirement is imposed between the last payload released and the spent third stage prior to the retro event. This is done to prevent the retro plume from impinging on the payload. The required separation distance can be achieved with an adequate coast period prior to retro fire, or with additional velocity imparted to the third stage using the ACS. Ultimately, the final separation obtained between the payloads and the third stage at reentry is affected by the time between retro fire and reentry and the number of retro motors used. Present designs have been completed for a suite of one, two, and four retro motors on the third stage.

3. AIRBORNE MECHANICAL INTERFACES

3.1 PAYLOAD INTERFACE

This section describes the details of the mechanical interface for the STARS I missile sys-tem. This information is intended for preliminary design purposes only. Details of the mechanical interfaces will be documented for each flight with an Interface Control Document (ICD).

3.1.1 Nose Fairing

The nose fairing (NF) is an aerodynamic heat shield designed to protect the payloads dur-ing the launch and boost phase of flight through second stage burnout. The interior sur-face of the fairing defines an optimum envelope for the payload.

The largest possible payload envelope would be the interior surface of a perfectly aligned NF prior to first stage ignition, when the payload is mounted on the payload plate. This optimum envelope is reduced by the initial prelaunch misalignment of the NF and payload, and by relative fairing-to-payload vibration and bending due to missile boost environments and loading conditions (see Section 5.). The static clearance constraints due to hardware toler-ances and payload misalignment must also be considered by payload designers.

Figure 3.1-1 shows the payload compartment inside contour. The points defining the in-side contour of the NF are listed in Table 3.1-1. If the longer version vehicle is used, the shroud is

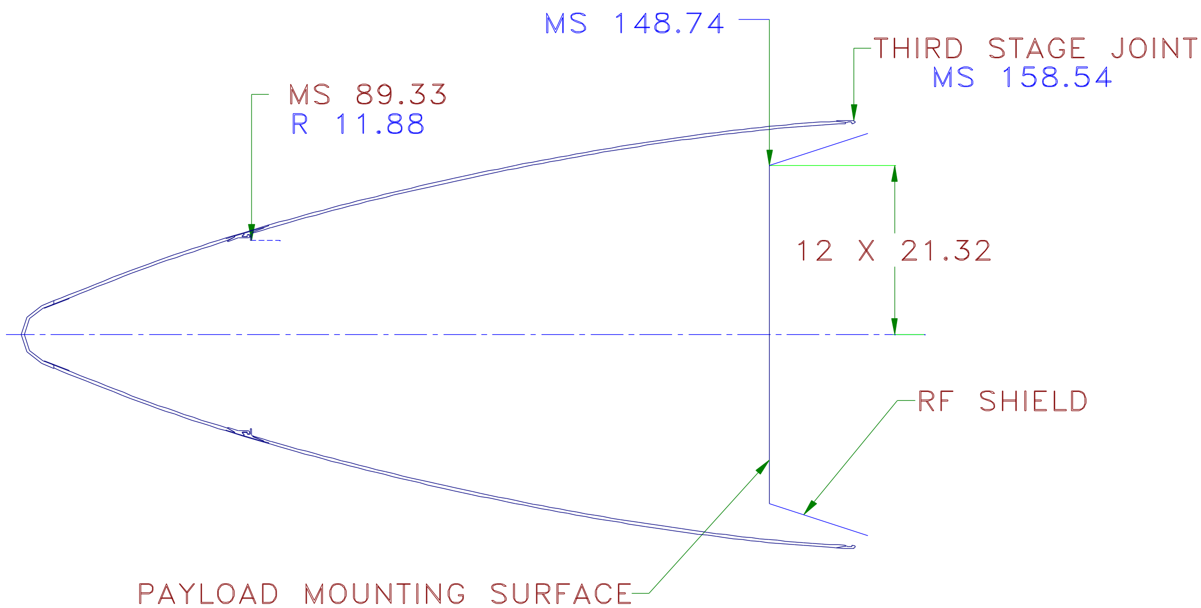

Figure 3.1-1 Payload Compartment Inside Contour

Table 3.1-1 Nose Fairing Inside Contour

MS (In)	Radius(In)		MS (In)	Radius(In)		MS (In)	Radius(In)		MS (In)	Radius(In)
			91.32	13.20		116.32	20.07		141.32	24.85
			92.32	13.52		117.32	20.30		142.32	25.00
			93.32	13.84		118.32	20.53		143.32	25.14
69.32	4.72		94.32	14.15		119.32	20.75		144.32	25.27
70.32	5.15		95.32	14.46		120.32	20.97		145.32	25.40
71.32	5.59		96.32	14.76		121.32	21.19		146.32	25.53
72.32	6.02		97.32	15.06		122.32	21.40		147.32	25.66
73.32	6.46		98.32	15.35		123.32	21.62		148.32	25.77
74.32	6.89		99.32	15.65		124.32	21.82		149.32	25.89
75.32	7.32		100.32	15.93		125.32	22.03		150.32	26.00
76.32	7.74		101.32	16.22		126.32	22.23		151.32	26.10
77.32	8.15		102.32	16.50		127.32	22.43		152.32	26.19
78.32	8.56		103.32	16.78		128.32	22.62		153.32	26.28
79.32	8.95		104.32	17.05		129.32	22.82		154.32	26.37
80.32	9.34		105.32	17.32		130.32	23.00		155.32	26.44
81.32	9.72		106.32	17.59		131.32	23.19		156.32	26.51
82.32	10.09		107.32	17.85		132.32	23.37		157.32	26.56
83.32	10.46		108.32	18.11		133.32	23.55			
84.32	10.82		109.32	18.36		134.32	23.73			
85.32	11.18		110.32	18.62		135.32	23.90			
86.32	11.53		111.32	18.87		136.32	24.06			
			112.32	19.12		137.32	24.23			
			113.32	19.36		138.32	24.39			
			114.32	19.60		139.32	24.55			
90.32	12.87		115.32	19.84		140.32	24.70			

extended 40 inches by adding a cylindrical section at MS 159.17. Thus, the cor-rect shroud MS numbers for the longer version are obtained by subtracting 40 from the MS numbers in Figure 3.1-1 and Table 3.1-1.

3.1.2 Payload Plate

The top of the payload plate is located at MS 148.74. The plate is a twelve-sided structure made out of AZ31B-H24 magnesium. A top view of the plate is shown in Figure 3.1-2. It has a nominal thickness of 0.460 inches from the center to a radius of 15.63 inches. The outer areas of the payload plate are thinned to a thickness of 0.125 inches for weight reduction. Twelve gussets connect the payload plate to the dodecagon structure to increase the plate's stiffness and decrease payload deflections due to missile boost environments and loading conditions as described in Section 5. Figure 3.1-2 also defines the location of three electrical connectors. Two of these connectors, Payload Discretes and Payload Umbilical and Telemetry System, are defined further in Section 4.1. The third connector is for the third stage retro motors.

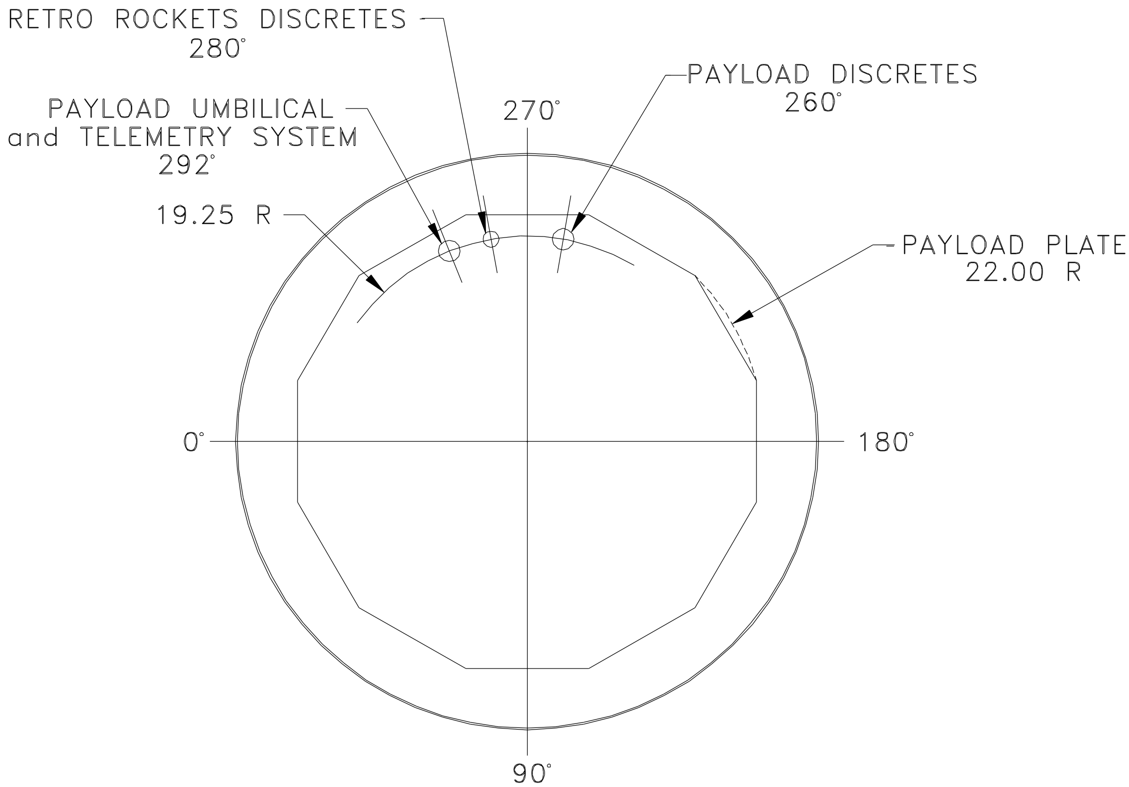

Figure 3.1-2 Payload Plate Top View

Payloads are normally attached to the payload plate in the 0.460 inch thick section. The number and size of bolts used to attach a payload to the plate must be sufficient to withstand the loads and payload frequency constraints described in Section 5. No payload mounting holes can be placed in the gusset or dodecagon mounting flange locations. These locations are defined in SNL drawing R08048[6].

The payload plate will be tailored to accommodate each mission. For multiple payload configurations, the outer areas of the plate can be thickened to 0.460 inches to support payloads and individual sides can be rounded. If the longer version STARS I vehicle is used, the radius of the payload plate can be increased by 3 inches. The electrical conectors can be moved if required by payload placement. An additional connector to handle Category A or B TM channels as described in Section 6.1 may be added. A request for all payload plate requirements must be received at SNL a minimum of 9 months before the scheduled launch date.

[6] *Payload Plate, Generic, STARS I,* SNL Drawing R08048, Latest Issue.

3.1.3 Third Stage Retro Motors

The third stage retro motors are mounted on the top outer edge of the payload plate. These motors come in a single or double assembly configuration. They are shown in Figures 3.1-3 and 3.1-4. The total number of motors used is dependent on the mission requirements.

3.2 STACKUP ALIGNMENT

The exact placement of all items mounted to the payload plate must be a coordinated effort between the payload designers and the Large Rocket Systems Department 9825 at SNL. Due to the constraints imposed by the TVC system of the second and third stage motors, the center of gravity (CG) of the STARS I vehicle must fall within a limited area. At SS motor burnout, the STARS I vehicle CG must lie within 0.23 inches of the missile centerline. The permissible TVC deflection due to a CG offset at TS motor burnout is ±2°, measured from the Orbus 1 motor nozzle pivot point. Ballast may be added to the missile if it is needed to meet the TVC system constraints.

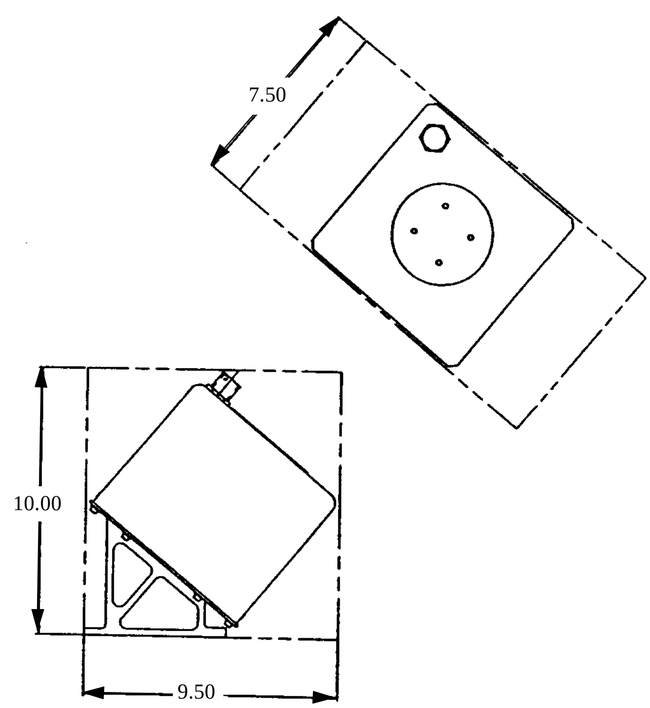

Figure 3.1-3 Third Stage Retro Motor Assembly (Single Motor)

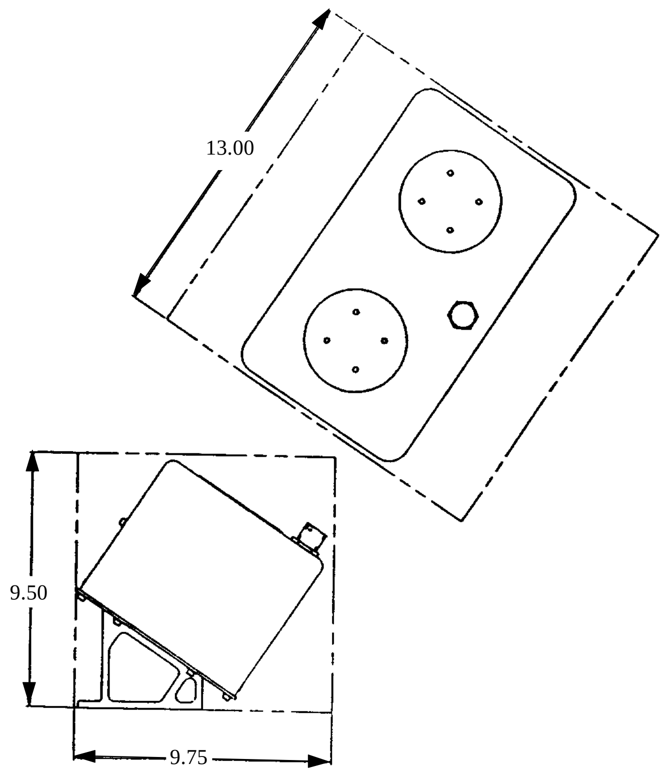

Figure 3.1-4 Third Stage Retro Motor Assembly (Double Motors)

3.3 PAYLOAD SEPARATION MECHANISMS

Typically, payload separation mechanisms and payload attachment systems are to be furnished with the payload by the payload designer. These mechanisms will be subject to the structural dynamic analyses described in Section 5.5.2. They also must be capable of withstanding the dynamic environments and design loads described in Sections 5.4 and 5.5. Typical separation techniques employ springloaded devices that impart from 2 to 15 feet/second separation velocities and 1 to 5 Hz roll rates to the payload(s) at separation. Since the STARS I third stage has the ability to back away from the payload, soft releases are acceptable. The responsibility for the payload separation system can be redefined on a case by case basis. SNL will accept the responsibility for providing the separation mechanism if it is determined to be in the best interest of both the payloader(s) and the STARS program.

3.4 INTERFACE CONTROL DOCUMENTS

Mechanical interface requirements for specific payload/STARS I configurations will be defined by ICDs as described in Section 10.2.1. Payload designers will support this activ-ity by providing the necessary inputs on their interfacing hardware and by attending review and approval meetings.

3.5 MECHANICAL INTERFACE VERIFICATION

Mechanical compatibility of the payload and its associated adapter, release mechanisms, and cabling with the STARS I vehicle shall be demonstrated by the physical interface checks that are described in Section 9.2.1.

4. ELECTRICAL INTERFACES

This section describes the payload interfaces that are available to connect the STARS I booster electrical systems with the ground control systems. Because of the unique requirements of different payload systems, the final details of the electrical interfaces will be documented in the appropriate ICDs.

4.1 PAYLOAD INTERFACE

The electrical interfaces between the payload systems and the STARS booster are effected at two connectors on the payload plate. The cables and connectors required to interface the payload with the booster must be provided by the payload organization.

4.1.1 Payload Connector Interface

The payload connector interfaces for the launch vehicle and ground support equipment are defined in Tables 4.1-1 and 4.1-2. The connectors at these interfaces are defined in Table 4.1-3.

Table 4.1-1 Payload/Launch Vehicle Interface

Connector Interface	Location	Usage
PF331/JF331	Payload Plate	Discretes interface to booster A&F electronics
PX32/JX32	Payload Plate	Access to payload umbilical and telemetry system on the payload side of the payload plate

Table 4.1-2 Ground Support Equipment/Payload Umbilical Interface

Connector Interface	Location	Usage
J306/P306	Auxiliary Equipment Building (AEB)	Access to payload umbilical.

Table 4.1-3 Payload/Launch Vehicle Connector Identification

Payload Designer		STARS Booster	
Connector Label	**Connector Part No.**	**Connector Label**	**Connector Part No.**
PF331	LJT06T21-41S	JF331	FLT07T21-41P
PX32	LJT06T25-61S	JX32	FLT07T25-61P
J306	LJT00T25-61S	P306	LJT06T25-61P

4.1.2 Payload Electrical Interface Circuits

The following subsections and Figure 4.1-1 and Table 4.1-4 identify and describe the electrical interface between the payload and the launch vehicle.

The capabilities and hardware definitions described below are the base line configuration. The payload designer must request use of the expanded capabilities described later in this section.

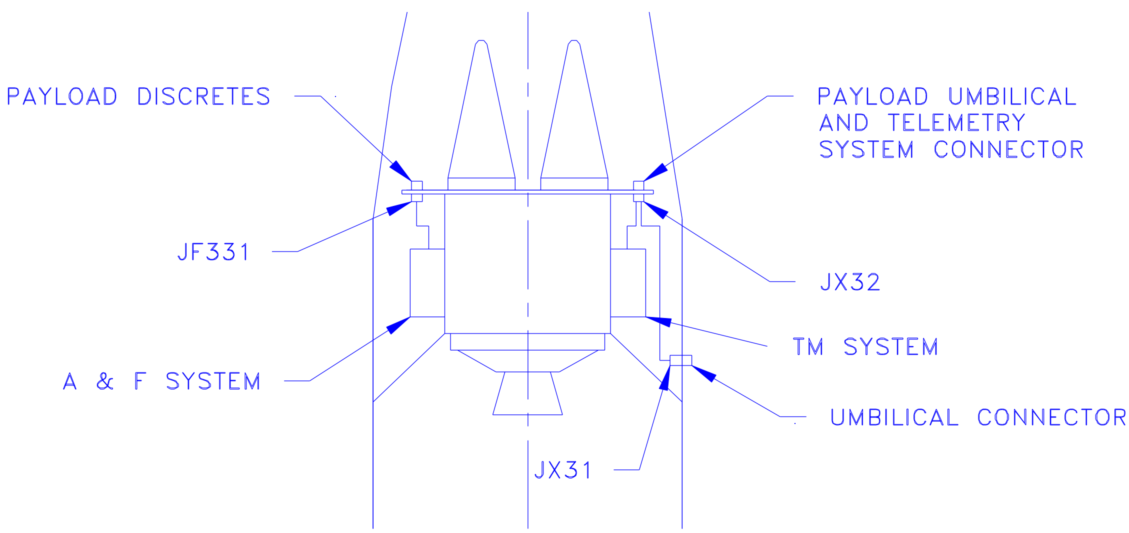

Figure 4.1-1 Payload Section Connector Interfaces

Table 4.1-4 Discretes Interface Connector

SINGLE		MULTIPLE	
Channel	Pin (JF331)	Channel	Pin (JF331)
1 A +	A	1 A +	b
1 A Return	B	1 A Return	c
1 B +	C	1 B +	d
1 B Return	D	1 B Return	e
2 A +	E	2 A +	g
2 A Return	F	2 A Return	h
2 B +	G	2 B +	i
2 B Return	H	2 B Return	j
3 A +	J	3 A +	f
3 A Return	K	3 A Return	q
3 B +	L	3 B +	k
3 B Return	M	3 B Return	m
4 A +	N	4 A +	n
4 A Return	P	4 A Return	p
4 B +	R	4 B +	r
4 B Return	S	4 B Return	s
5 A +	T		
5 A Return	U		
5 B +	V		
5 B Return	W		
6 A +	X		
6 A Return	Y		
6 B +	Z		
6 B Return	a		

4.1.2.1 Payload Discretes

The payload discretes are supplied through connector JF331 (see Figure 4.1-1 and Table 4.1-4). The plus (+) and return of each discrete is cabled in 20 AWG twisted-pair wire. Ground safety requirements must be complied with for discrete circuits used for bridge-wire initiated ordnance (see Subsections 4.4.4 and 4.4.5 on cable requirements). Also, the system checkout procedures should be considered in the payload systems circuit design. The discrete monitoring capability of event occurrence and current flow levels exists in the STARS I booster A&F electronics.

- Discrete Standard Capability
  1. Six events requiring dual discretes and one event requiring four sets of dual discretes activated simultaneously are available for Channel A and Channel B.
  2. Channel A and Channel B are activated simultaneously for each event.
  3. The total number of discretes available is ten for Channel A and ten for Channel B in the standard configuration.

- Discretes Description

    1. An event requiring a dual channel discrete may use the line referred to as Single Discrete 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, and 6B. The pin assignments are shown in Table 4.1-4.
    2. An event requiring up to four dual channel discretes activated simultaneously may use the lines referred to as Multiple Discretes 1A, 1B, 2A, 2B, 3A, 3B, 4A, and 4B. The pin assignments are shown in Table 4.1-4.

    NOTE: These ten discretes represent the base line configuration. If additional discretes are needed see Expanded Discrete Capabilities for further information.

    3. The open circuit voltage is 28 V ± 4 V.
    4. The nominal peak current into 1 ohm is 10.7 A ± 1.5 A.
    5. The normal current at 5 msec with a 1 ohm load is greater than 8 A for each discrete, but will be less depending upon the number of discretes utilized simultaneously for a given event.
    6. The normal current at 5 msec with a 1 ohm load is greater than 6 A each for the multiple of four. The energy is delivered through 1.62 ohms to the load.
    7. A maximum of four switches of each Channel A and B can be activated simultaneously.
    8. Switches are closed for 10 msec, but this can be changed with the flight sequencing software.

- Expanded Discrete Capabilities

    1. Independent activation of the discretes in Channels A and B is possible through the modification of the sequencer software.
    2. With modifications to the base line connectors and cabling, an expansion to 15 single discretes and 5 multiples (of four discretes) is available per channel.

4.1.2.2 Payload/Telemetry Interface

The JX32 connector contains several TM monitoring lines. The lines in this connector can be used for monitoring TM and/or payload umbilical functions. See Section 4.2.1 for a description of the electrical interface. If required, an additional connector can be added to the payload plate to support additional TM functions. Section 6. of this document provides a further description of the instrumentation capability available to the payload designer.

If possible, the payload designer(s) should incorporate some means for monitoring and confirming the payload separation event through the TM system.

4.2 PAYLOAD UMBILICAL AND GROUND SUPPORT

4.2.1 Payload Umbilical

Access to the lines extending to the external payload systems umbilical on the payload side of the payload plate is supplied through connector JX32 (see Figure 4.2-1). Up to 60 lines coming from JX32 can be routed directly to the JX31 umbilical connector. JX32 is a 61 pin connector in which pin "D" is not used.

4.2.2 Ground Support

It is up to the payload designers to supply their own ground support equipment. In the future, SNL will have remote monitoring capabilities of the payload umbilical voltages and resistances from the Launch Operation Building (LOB).

4.3 PAYLOAD SUPPORT EQUIPMENT CRITERIA

Payload support equipment (SE) provided for use in STARS facilities at KTF must be designed to comply with the criteria set forth in this section. It may be installed in the Auxiliary Equipment Building (AEB), the Assembly Building 2 (AB2), the Assembly Building 3 (AB3), or the LOB. Refer to Sections 7.1.1, 7.1.3, and 7.1.4 for SE size restrictions. Compliance with these criteria will allow for an orderly and smooth integration of the payload systems with KTF operations.

4.3.1 SE Electrical Interface and Interconnection

All of the lines going from connector JX32 on the payload plate, down to connector P306 in the AEB are 20-AWG conductors. Access to the payload umbilical can be made in the AEB through connector P306 (see Figure 4.2-1).

There are 100 lines from the Payload Console in the LOB to the Payload Control Panel in the AEB in two 25 pair cables for payload monitor and control. One cable is terminated at each end with PT00P-22-55S connectors and the other with PT00P-24-61S connectors. The connectors are essentially connected pin-to-pin as shown in Figures 4.3-1 and 4.3-2. The conductors are 20-AWG and have a nominal impedance of 30 ohms. For further information contact SNL's Range & Small Rocket Systems Department 9819.

Payload Plate	Missile Skin		Missile Tower		AEB
JX32	JX31	PX31	PX30	JX30	P306
A	A	A	A	A	A
B	B	B	B	B	B
C	C	C	C	C	C
E	E	E	E	E	E
F	F	F	F	F	F
G	G	G	G	G	G
H	H	H	H	H	H
J	J	J	J	J	J
K	K	K	K	K	K
L	L	L	L	L	L
M	M	M	M	M	M
N	N	N	N	N	N
P	P	P	P	P	P
R	R	R	R	R	R
S	S	S	S	S	S
T	T	T	T	T	T
U	U	U	U	U	U
V	V	V	V	V	V
W	W	W	W	W	W
X	X	X	X	X	X
Y	Y	Y	Y	Y	Y
Z	Z	Z	Z	Z	Z
a	a	a	a	a	a
b	b	b	b	b	b
c	c	c	c	c	c
d	d	d	d	d	d
e	e	e	e	e	e
f	f	f	f	f	f
g	g	g	g	g	g
h	h	h	h	h	h
i	i	i	i	i	i
j	j	j	j	j	j
k	k	k	k	k	k
m	m	m	m	m	m
n	n	n	n	n	n
p	p	p	p	p	p
q	q	q	q	q	q
r	r	r	r	r	r
s	s	s	s	s	s
t	t	t	t	t	t
u	u	u	u	u	u
v	v	v	v	v	v
y	y	y	y	y	y
z	z	z	z	z	z
AA	AA	AA	AA	AA	AA
BB	BB	BB	BB	BB	BB
CC	CC	CC	CC	CC	CC
DD	DD	DD	DD	DD	DD
EE	EE	EE	EE	EE	EE
FF	FF	FF	FF	FF	FF
GG	GG	GG	GG	GG	GG
HH	HH	HH	HH	HH	HH
JJ	JJ	JJ	JJ	JJ	JJ
KK	KK	KK	KK	KK	KK
LL	LL	LL	LL	LL	LL
MM	MM	MM	MM	MM	MM
NN	NN	NN	NN	NN	NN
PP	PP	PP	PP	PP	PP

Figure 4.2-1   Payload Umbilical Line Definition

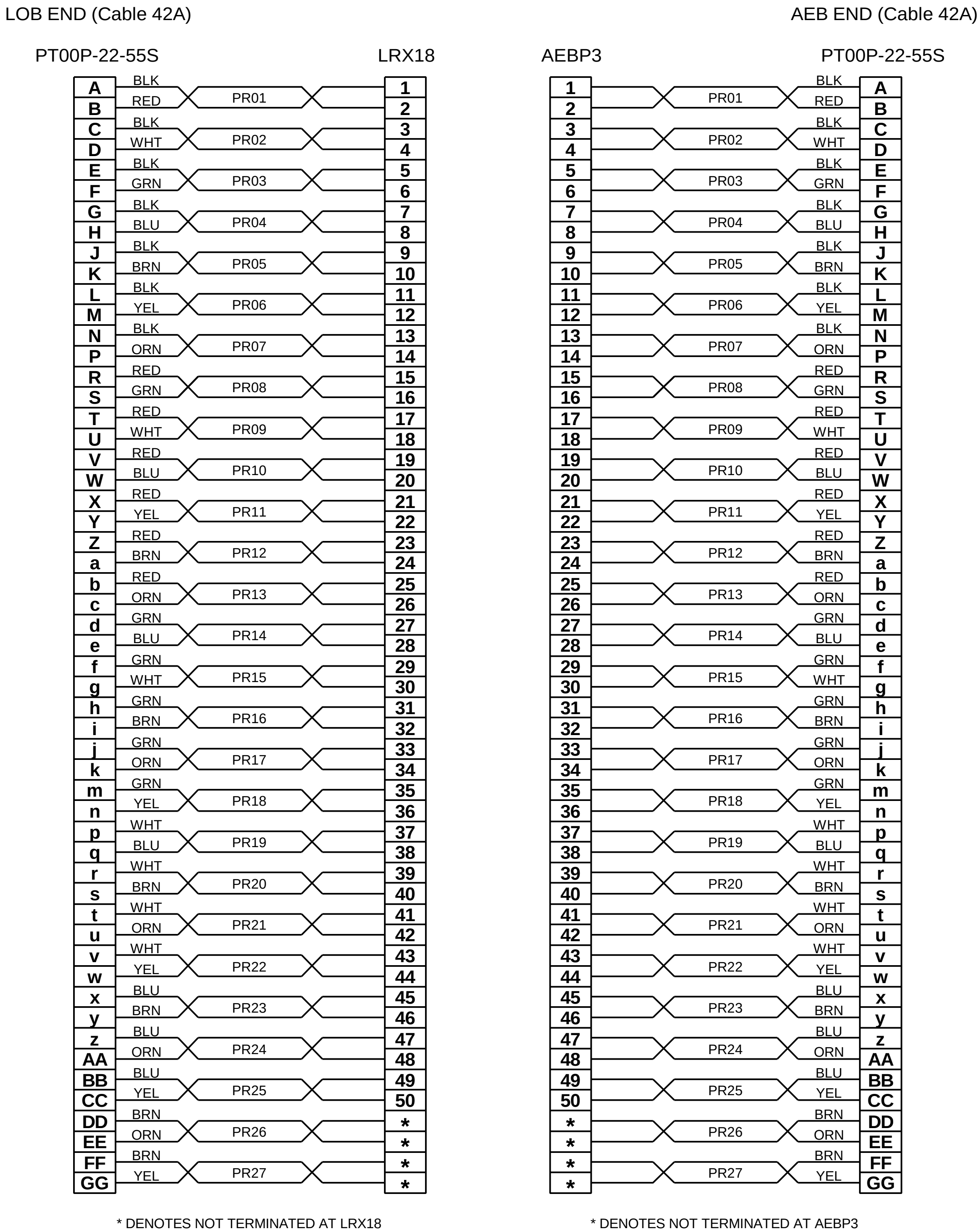

Figure 4.3-1 STARS Payload Control Cable 42A

LOB END (Cable 42B)

PT00P-24-61S	Wire	Pair	LRX18
A	BLK	PR01	51
B	RED	PR01	52
C	BLK	PR02	53
D	WHT	PR02	54
E	BLK	PR03	55
F	GRN	PR03	56
G	BLK	PR04	57
H	BLU	PR04	58
J	BLK	PR05	59
K	BRN	PR05	60
L	BLK	PR06	61
M	YEL	PR06	62
N	BLK	PR07	63
P	ORN	PR07	64
R	RED	PR08	65
S	GRN	PR08	66
T	RED	PR09	67
U	WHT	PR09	68
V	RED	PR10	69
W	BLU	PR10	70
X	RED	PR11	71
Y	YEL	PR11	72
Z	RED	PR12	73
a	BRN	PR12	74
b	RED	PR13	75
c	ORN	PR13	76
d	GRN	PR14	77
e	BLU	PR14	78
f	GRN	PR15	79
g	WHT	PR15	80
h	GRN	PR16	81
i	BRN	PR16	82
j	GRN	PR17	83
k	ORN	PR17	84
m	GRN	PR18	85
n	YEL	PR18	86
p	WHT	PR19	87
q	BLU	PR19	88
r	WHT	PR20	89
s	BRN	PR20	90
t	WHT	PR21	91
u	ORN	PR21	92
v	WHT	PR22	93
w	YEL	PR22	94
x	BLU	PR23	95
y	BRN	PR23	96
z	BLU	PR24	97
AA	ORN	PR24	98
BB	BLU	PR25	99
CC	YEL	PR25	100
DD	BRN	PR26	*
EE	ORN	PR26	*
FF	BRN	PR27	*
GG	YEL	PR27	*

* DENOTES NOT TERMINATED AT LRX18

AEB END (Cable 42B)

AEBP3	Pair	Wire	PT00P-24-61S
51	PR01	BLK	A
52	PR01	RED	B
53	PR02	BLK	C
54	PR02	WHT	D
55	PR03	BLK	E
56	PR03	GRN	F
57	PR04	BLK	G
58	PR04	BLU	H
59	PR05	BLK	J
60	PR05	BRN	K
61	PR06	BLK	L
62	PR06	YEL	M
63	PR07	BLK	N
64	PR07	ORN	P
65	PR08	RED	R
66	PR08	GRN	S
67	PR09	RED	T
68	PR09	WHT	U
69	PR10	RED	V
70	PR10	BLU	W
71	PR11	RED	X
72	PR11	YEL	Y
73	PR12	RED	Z
74	PR12	BRN	a
75	PR13	RED	b
76	PR13	ORN	c
77	PR14	GRN	d
78	PR14	BLU	e
79	PR15	GRN	f
80	PR15	WHT	g
81	PR16	GRN	h
82	PR16	BRN	i
83	PR17	GRN	j
84	PR17	ORN	k
85	PR18	GRN	m
86	PR18	YEL	n
87	PR19	WHT	p
88	PR19	BLU	q
89	PR20	WHT	r
90	PR20	BRN	s
91	PR21	WHT	t
92	PR21	ORN	u
93	PR22	WHT	v
94	PR22	YEL	w
95	PR23	BLU	x
96	PR23	BRN	y
97	PR24	BLU	z
98	PR24	ORN	AA
99	PR25	BLU	BB
100	PR25	YEL	CC
*	PR26	BRN	DD
*	PR26	ORN	EE
*	PR27	BRN	FF
*	PR27	YEL	GG

* DENOTES NOT TERMINATED AT AEBP3

Figure 4.3-2 STARS Payload Control Cable 42B

4.3.2 Power Constraints

All power that is connected to missile systems and payloads must be stringently controlled with key lockout safeguards. The AEB has two 15 amp single phase 120 volt AC circuits available for payload use. These two circuits have all of the necessary safeguards. They can be controlled independently from the LOB. The assembly buildings have 75 amp service.

4.3.3 System Safeguards

All electrical connections with the launch vehicle through the umbilical cables are protected with transient suppression devices. These were installed to prevent inadvertent firing of detonators prior to launch. While these devices provide some protection for electronics, they were installed for personnel safety. The payload designer is responsible for any additional protection the payloads may require.

4.4 PAYLOAD SIMULATORS

Electrical system tests and various mechanical tests are conducted on the combined booster/payload assembly. The objective of these tests is to achieve a high level of confidence that the missile and payloads function correctly and do not damage or degrade each other or other payloads. Payload simulators are required whenever the actual payloads cannot be used.

4.4.1 Mechanical Simulator Criteria

A flight-configured payload adapter/separation mechanism, or an equivalent mechanical simulator, must be provided to support configuration modal tests, Section 5.5.2.5, and physical interface checks, Section 9.2.1. If a mechanical simulator is selected, it must exhibit the same mass, stiffness and damping properties as the actual payload. The simulator must utilize flight-configured hardware for the interface mating hardware and payload adapter cabling. The cabling is needed to verify cable tiedown locations.

4.4.2 Electrical Simulator Criteria

Flight configured payloads or equivalent electrical simulators will be provided to support electrical system tests defined in Section 9.2.1. The electrical simulators must present realistic electrical loads to the missile electronics with sufficient instrumentation or other indicators to confirm operation occurred.

4.4.3 Data Requirements

The following simulator data will be provided to the Large Rocket Systems Department 9825 at SNL to verify compliance with criteria given in Sections 4.4.1 and 4.4.2:

1. Simulator production drawings (preliminary and final).
2. Electrical schematics (functional).

4.5 ELECTRICAL GROUND, BONDING, AND SHIELDING REQUIREMENTS

4.5.1 Primary Power

The payload primary electrical power distribution system power negatives must be grounded to a structure at a single point. This single point is referred to as Vehicle Ground Point (VGP).

If there is more than one power source, and if the power distribution system for each is electrically isolated from the other, each may have its own VGP connected to the vehicle structure as near as practicable to that power source. [Subsection 4.5.5 describes the Electro-Explosive Device (EED) firing circuits.] There will be no primary or secondary power or signal circuits common to such independent and electrically isolated power sources for intended power exchanges. The grounding of the interconnecting wiring should not inadvertently connect together two or more of the VGPs.

Direct-current output from power supplies using a common input/output return (such as series regulators) must not have the return connected to ground at the regulator.

All primary power distribution shall be treated as having the negative side at a different potential from the earth ground potential, i.e., both positive and negative leads shall be isolated from structure and earth ground by at least 1 megohm with the VGP and all load circuits disconnected.

> **NOTE:** The structure is NOT to be used as an intentional current carrying conductor.

4.5.2 Secondary Power

Secondary power supplies must be isolated from the primary power sources by a minimum DC resistance of 1 megohm.

4.5.3 Dissimilar Metals

Payload designers should be aware of the potential for galvanic corrosion of joined dissimilar metal. However, there are no special requirements regarding payload assembly techniques. In contrast to vehicles that must withstand long periods of storage, STARS I launch vehicles are scheduled to be assembled starting approximately a month prior to launch. During this time, the vehicle will be in a controlled environment. A further explanation of the controlled environmental conditions can be found in Section 7. Delays can be expected to occur, however. It is expected the time between assembly and launch should be no longer than two months. Special anti-corrosion procedures are left to the discretion of the payload designer.

4.5.4 Shielding

Shielding is required on detonator cables to preclude the inadvertent firing of detonators. (The outer conductor of a coaxial RF cable is not a shield. It is an outer conductor.) Any additional shielding is optional. Neither shields nor the missile structure shall be used to intentionally conduct current. Any circuits that will carry large currents or high frequency signals should be brought to the attention of SNL early in the payload design.

4.5.5 Electro-Explosive Device Firing Circuits

The return conductors must be isolated from the structure by a minimum resistance of 1 megohm. EEDs must be referenced to the battery negative only. These criteria are for safety reasons rather than for Electromagnetic Interference (EMI) control.

Firing circuit conductors shall be twisted, shielded pairs. No EED circuit will share a return with another circuit.

A safing circuit shall be used that will result in one of the configurations shown in Figures 4.5-1 or 4.5-2. Figure 4.5-1 shows the preferred circuit. Figure 4.5-2 is an alternate circuit that is acceptable if it is genuinely impractical to implement the one shown in Figure 4.5-1.

There are no specific sources of electromagnetic energy that have been identified near the launch area that are strong enough to pose an electromagnetic problem. Consequently, there is no specified minimum amount of shielding that is required. Good shielding practice results in shielding with these attributes:

- at least 95% of the cable is visibly covered with shielding.
- circumferential terminations at connectors are used.
- any gaps in woven braiding or foil wrap are no larger than five millimeters in any dimension.

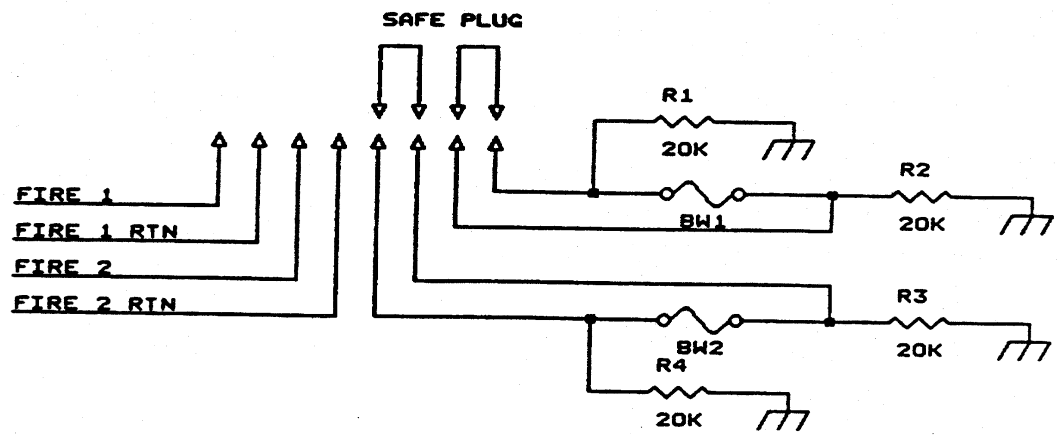

Figure 4.5-1 Preferred Safing Scheme

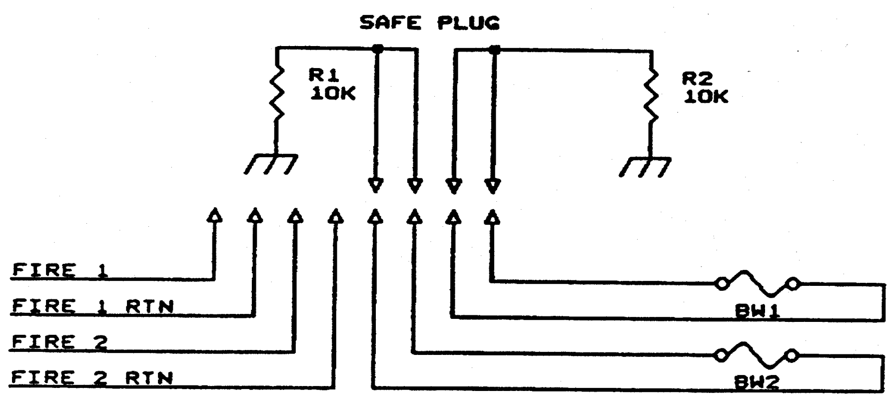

Figure 4.5-2 Acceptable Safing Scheme

4.6 ELECTRICAL END-TO-END CIRCUITRY

An electrical end-to-end interconnecting diagram and schematic wiring drawings will be generated for the total payload/STARS I system by SNL.

These drawings are required for evaluation of the functional adequacy of the interfacing payload and booster electrical systems. In support of this effort, production wiring diagrams and electrical schematic diagrams, which include black-box first active elements, are required from the payload designer.

4.7 INTERFACE CONTROL DOCUMENTS

Electrical interface requirements for specific payload/STARS I configurations will be defined by ICDs as described in Section 10.2.1. Payload designers will support this activity by providing necessary inputs on their interfacing hardware and by attending review and approval meetings.

4.8 ELECTRICAL INTERFACE VERIFICATION

Electrical compatibility of the payload electronics and the STARS I booster's electronics will be demonstrated by electrical system tests, as described in Section 9.2.1.

5. PAYLOAD ENVIRONMENT

The environmental conditions experienced by the payload during pre-launch, launch, and boost flight are presented in this section. Detailed discussions of the heating, accelertion, vibration, and shock environments are included. Also discussed are the design loads and the structural dynamic requirements for the payload. The payload designer test item must be capable of operating after being tested to the specified environments. In establishing payload testing requirements, it should be recognized that the combined effects of all the applicable environments of Section 5. must be considered.

5.1 PRE-LAUNCH, LAUNCH, AND IN-FLIGHT HEATING

Before the payloads are mated to the missile, they are maintained in the environmentally controlled payload assembly areas defined in Section 7. During the pre-launch phase of the flight, temperature control of the missile is maintained in the Missile Service Tower (MST). Payload temperature critical operations should be identified as soon as possible to allow for special operations of cooling or heating in the payload assembly areas and in the MST. The MST is retracted at approximately launch minus three hours during the missile countdown. At that time, the missile temperature is a function of the ambient tempera-ture, internal heat generation from the missile and payload electronics, and the thermal in-ertia of the missile. Because of temperature considerations for the second stage, the temperature will be maintained at 76°±4°F.

A laminated, wooden (Sitka Spruce) NF protects the payload during the launch and boost phases of flight. An ablative coating applied to the exterior surface of the NF is designed to insure that the internal black body temperature of the NF does not exceed 130°F. The NF is removed shortly after second stage burnout.

Payload designers must identify the payload hardware that is temperature-critical and specify any special processing considerations that are required.

5.2 LAUNCH AND IN-FLIGHT PRESSURE VENTS

The payload compartment is vented to minimize external/internal pressure differences. The NF bayonet joint permits air to bleed out from the payload compartment at a controlled rate. The payload compartment vent area resulting from this joint design is 2.65 ± 1.08 in^2.

Free air passage is provided between the payload compartment and the TS electronic component section. This vent area is 2.41 ± 0.17 in^2.

5.3 ACCELERATIONS

The longitudinal and lateral accelerations experienced by the payload during powered flight are dependent upon the structural and inertial properties of the payload system, the flight trajectory, and the delivered motor performance.

The rigid body longitudinal accelerations of the STARS I missile depend primarily upon motor performance and the total missile weight. Figure 2.2-5 presents the longitudinal accelerations of the missile as a function of time for a Type I mission with a 300 lb payload. These are rigid-body accelerations of the complete missile based on nominal motor performance. These accelerations are intended to be used as a general description of flight environment. They are not intended for determining structural loads.

The lateral acceleration levels seen by the payload are produced by rigid-body motions and elastic-body responses. Both are a function of the payload/launch vehicle configuration. Scheduled turning maneuvers of the launch vehicle will produce lateral accelerations of less than 5 g's.

Structural analyses incorporating a dynamic model of the payload must be performed to determine payload design loads. This is discussed further in Section 5.5.

5.4 DYNAMIC ENVIRONMENTS

Payload section vibration and shock environmental criteria, based on flight data, are defined in the following paragraphs. The payload designer supplied components must be capable of withstanding these environments. Verification that the payload has passed environmental testing must be submitted to the Large Rocket Systems Department 9825 at SNL. No operating vibration environment is specified for time periods subsequent to payload separation.

5.4.1 Vibration Environment

The expected random vibration levels for the payload longitudinal and transverse axes are given in Figures 5.4-1 and 5.4-2. The points for the two spectra are listed in Tables 5.4-1 and 5.4-2. These spectra are an envelope of first, second, and third stage powered flight. All test inputs apply to the payload/vehicle interface. The equivalent overall levels are 6.8 G-rms for the payload longitudinal axis and 6.7 G-rms for the transverse axes. The duration for this test series is 30 seconds in each axis.

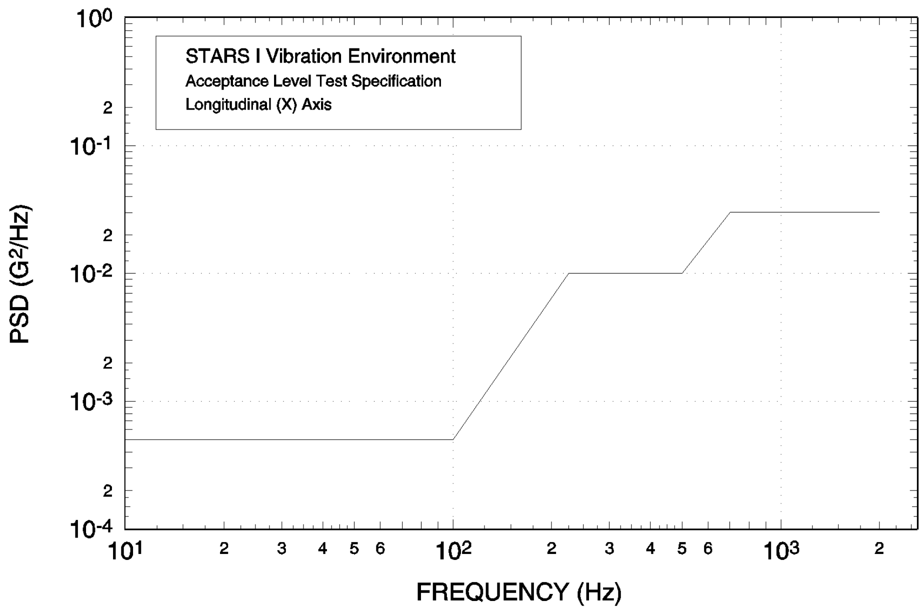

Figure 5.4-1 STARS I Longitudinal Axis Random Vibration Environment

Table 5.4-1 STARS I Longitudinal Axis Random Vibration Spectrum Points

Frequency (Hz)	**Power Spectral Density (G^2/Hz)**
10	0.0005
100	0.0005
225	0.0100
500	0.0100
700	0.0300
2000	0.0300

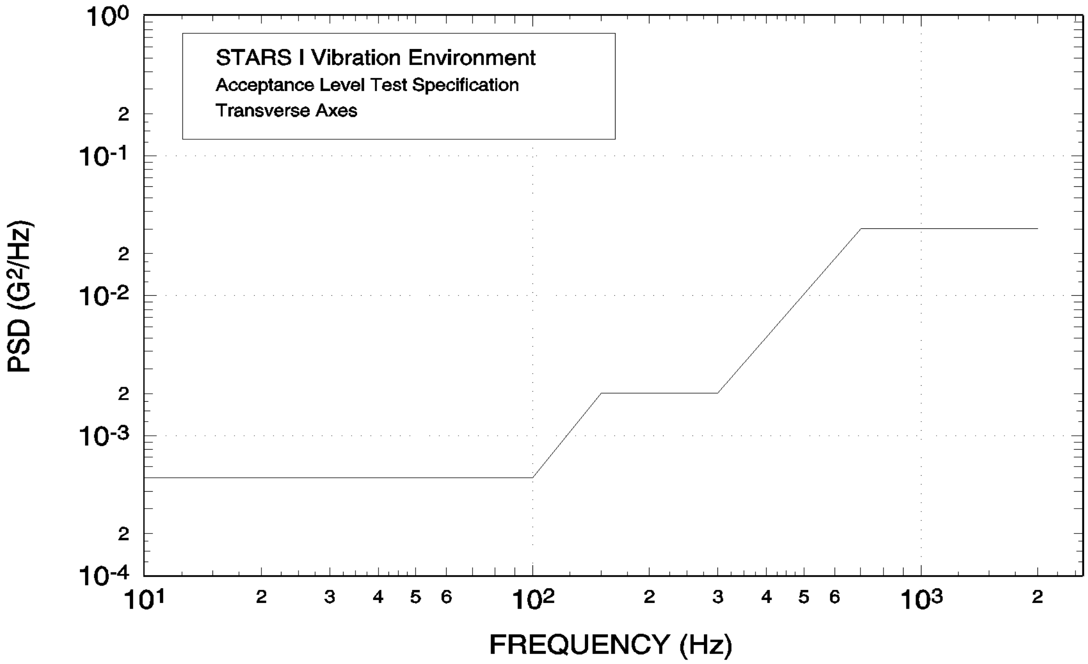

Figure 5.4-2 STARS I Transverse Axes Random Vibration Environment

Table 5.4-2 STARS I Transverse Axes Random Vibration Spectrum Points

Frequency (Hz)	**Power Spectral Density (G^2/Hz)**
10	0.0005
100	0.0005
150	0.0020
300	0.0020
700	0.0300
2000	0.0300

5.4.2 Acoustic Environment

The maximum expected acoustic environment a payload will experience during flight is shown in Figure 5.4-3. These levels are sound pressure levels outside the payload compartment on the nose fairing surface. The levels inside the payload compartment are expected to be lower. The peak sound pressure level environment occurs at launch.

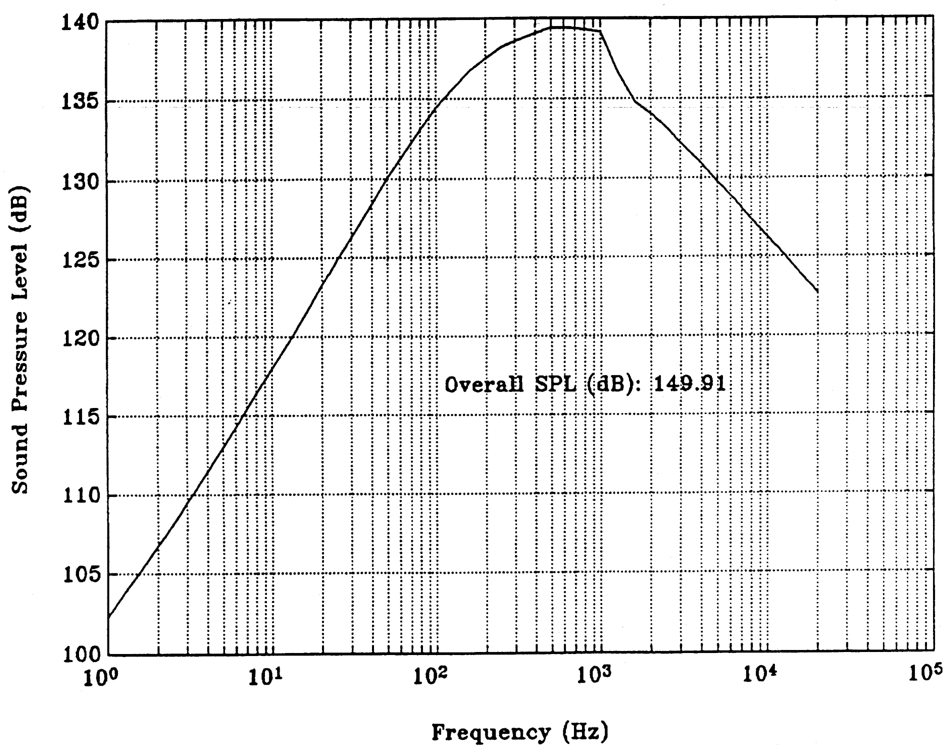

Figure 5.4-3 STARS I Payload Acoustic Environment at Launch

5.4.3 Shock Environment

5.4.3.1 STARS I Launch Vehicle to Payload

The envelopes of the expected flight-shock environments seen by the payload are defined by the shock response spectrums for the longitudinal and transverse axes in Figures 5.4-4 and 5.4-5. Points for the spectra are listed in Table 5.4-3 and 5.4-4, respectively. The events that contribute to this environment are first, second, and third stage motor ignition and the interstage pressurization event that occurs just prior to second stage separation. The envelope of the pyro-shock environment due to SS and NF separation is defined by the shock response spectrum in Figure 5.4-6. The points for this spectrum are listed in Table 5.4-5. These spectra define the shock environment at the base of the payload system, and apply to all payload axes.

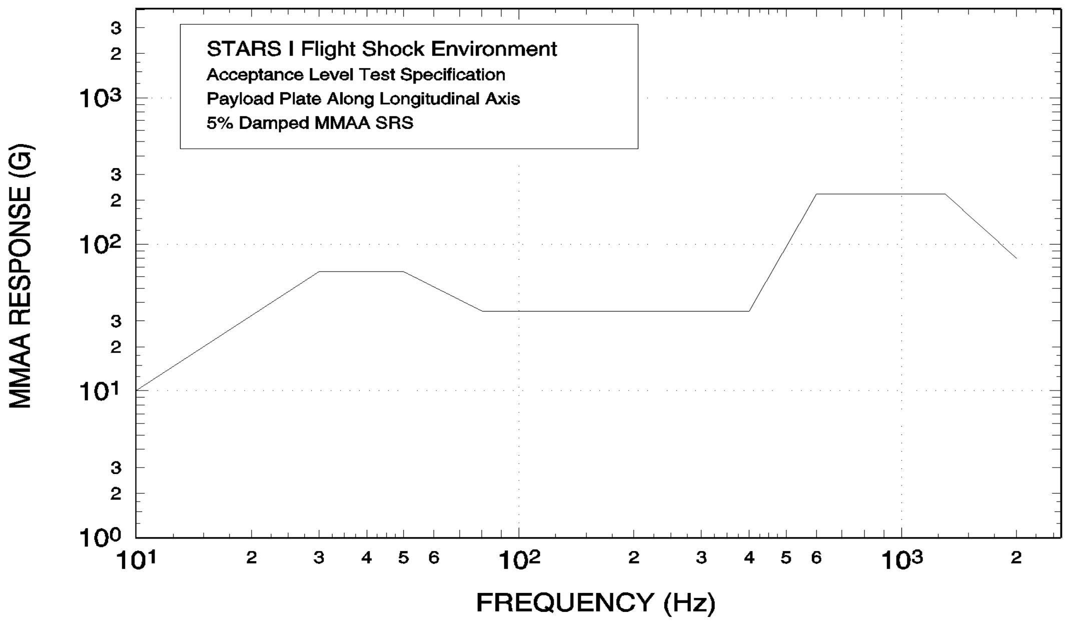

Figure 5.4-4 STARS I Longitudinal Axis Flight-Shock Environment

Table 5.4-3 STARS I Longitudinal Axis Flight-Shock Spectrum Points

Frequency (Hz)	Acceleration Amplitude (G's)
10	10
30	65
50	65
80	35
400	35
600	220
1300	220
2000	80

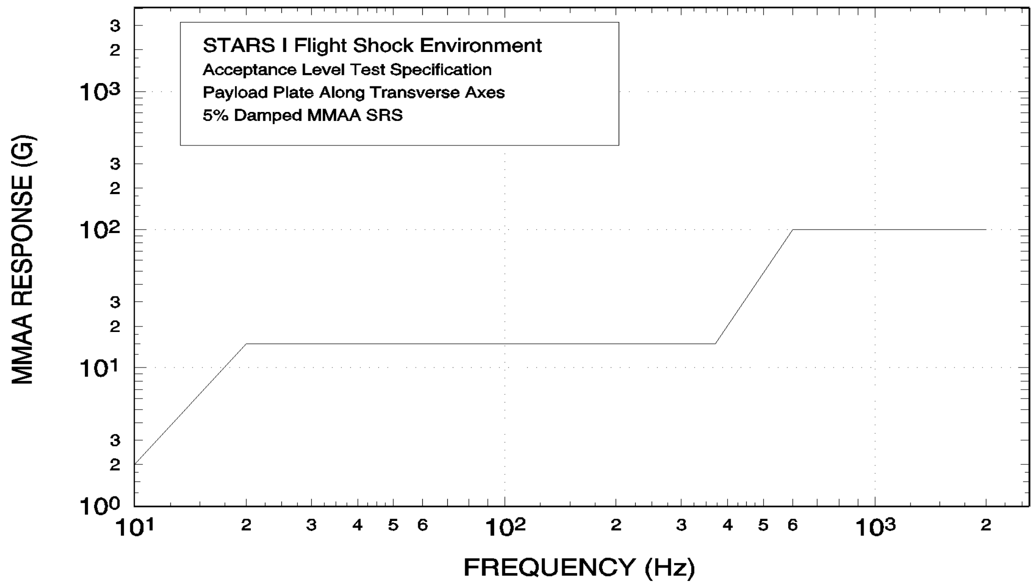

Figure 5.4-5 STARS I Transverse Axes Flight-Shcok Environment

Table 5.4-4   STARS I Transverse Axes Flight-Shock Spectrum Points

Frequency (Hz)	Acceleration Amplitude (G's)
10	2
20	15
370	15
600	100
2000	100

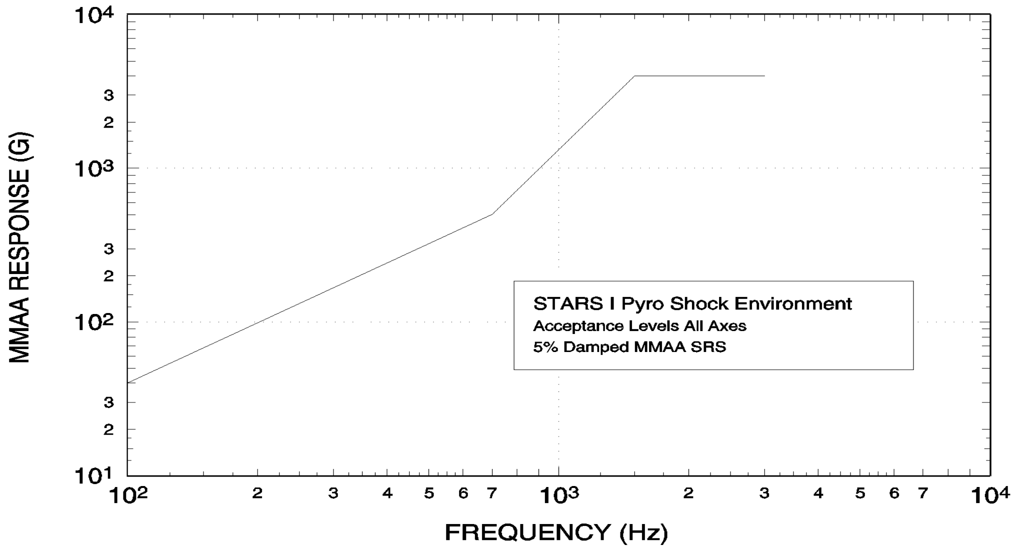

Table 5.4-6 STARS I Pyro-Shcok Environment

Table 5.4-5 Pyro-Shock Spectrum Points

Frequency (Hz)	Acceleration Amplitude (G's)
100	40
700	500
1500	4000
3000	4000

5.4.3.2 Payload to STARS I Launch Vehicle

The payload should be designed to limit the shock environment imposed upon the launch vehicle during the separation event. The shock levels must be below those shown in Figure 5.4-7. Table 5.4-6 lists the transition points. This shock spectrum is applicable to all three payload axes as measured at the payload/vehicle interface.

Payload designers must submit verification of RV separation shocks, along with separtion induced torques and loads, to the Large Rocket Systems Department 9825 at SNL.

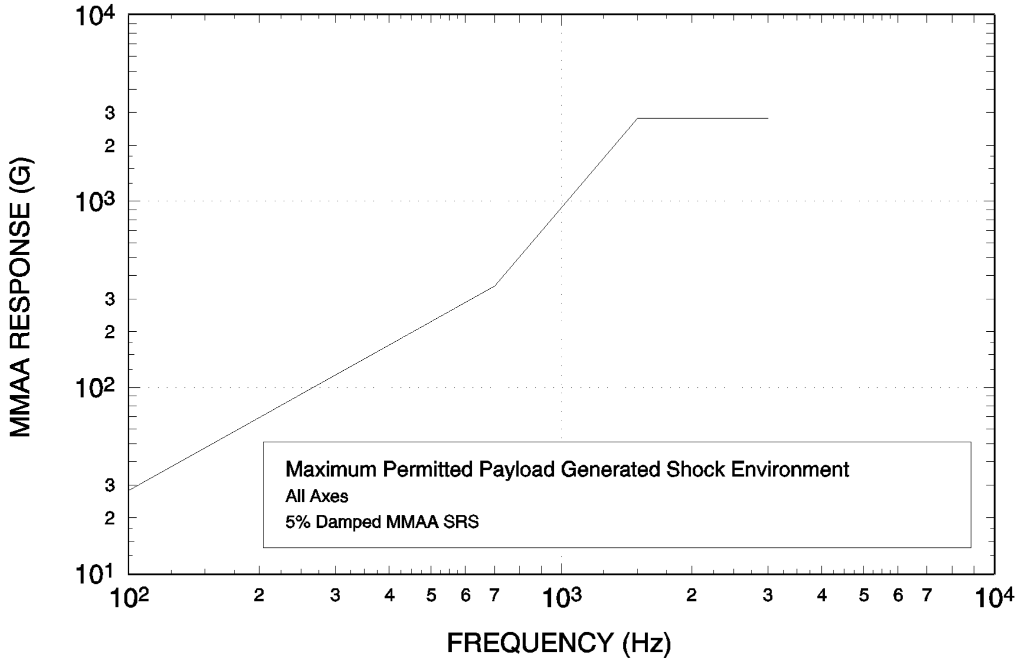

Figure 5.4-7 Maximum Permitted Separation Shocks at the Payload/Missile Interface

Table 5.4-6 Maximum Permitted Separation Shock Spectrum Points

Frequency (Hz)	Acceleration Amplitude (G's)
100	28
700	350
1500	2800
3000	2800

5.5 PAYLOAD DESIGN LOAD REQUIREMENTS

The loading environment on a payload system is described in this section. The payload system must be designed and verified to be capable of withstanding these loads. Lateral and longitudinal loads are given. These must be combined simultaneously to calculate the total design load. The given design loads represent ultimate load values. The payload shall be capable of withstanding these loads without catastrophic structural failure. Design limit loads can be found by dividing the ultimate loads by 1.25. The payload shall be capable of withstanding the limit loads without structural yielding.

Load values to be used during payload system development and structural verification testing are calculated using the load factors given in Section 5.5.1. These loads yield an equivalent static load to be applied to the payload at its CG, from which the axial, shear, and bending loads at any payload section may be calculated. Section 5.5.2 describes the structural dynamic data required from the payload designer. This data is used by SNL to verify the structural loads.

The design values given in the Section 5.5.1 are derived from Polaris data. They are expected to be conservative for all staging events.

5.5.1 Payload Design Loads

This section defines the payload design load factors to be applied to all payloads. One set of design loads covers the entire flight. The lateral and longitudinal design load factors must be applied simultaneously. Longitudinal loads can be either tensile or compressive. In general, the payload orientation is arbitrary with respect to the missile coordinate system. Moreover, a payload may be non-symmetric, thereby possessing a direction of least strength. The loads must be assumed to occur in the direction of payload least strength.

The design load factors are ±5 g lateral and -15 g longitudinal. The design loads at any payload section, including the payload/missile interface, are defined by:

$$F_a = -(15.0)W \text{ (compressive)} \qquad \text{(EQ 1)}$$

$$F_s = (5.0)W \qquad \text{(EQ 2)}$$

$$M = (5.0)l_{cg}W \qquad \text{(EQ 3)}$$

where

F_a = section force in the longitudinal (axial) direction

F_s = section force in the lateral (shear) direction

M = section bending moment

l_{cg} = distance from the payload CG to the section of interest

W = payload weight

These terms are indicated schematically in Figure 5.5-1.

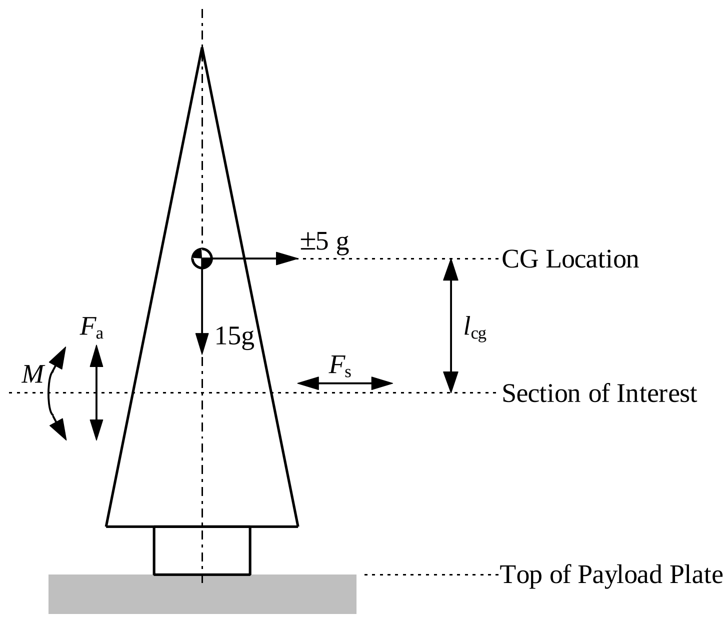

Figure 5.5-1 Payload Design Load Schematic

5.5.2 Structural Dynamic Requirements for the Payload

Structural dynamic data for the payload system is required for two reasons. First, the missile control system design requires an accurate knowledge of the elastic properties of the entire missile system. Second, the resulting models are used in making the structural loads calculations.

For the purpose of this section, the payload is defined to consist of all components of the payload system down to and including the payload plate interface. This includes all attachment assemblies, such as mounting feet and/or ejector mechanisms. The reference configuration is a fixed-base payload, which denotes the payload is rigidly attached at the payload plate interface. Payload frequencies denote the natural frequencies of the fixed-base payload. For multiple payload configurations, each payload must be considered separately.

5.5.2.1 Payload Design Frequencies

The flexibility of the payload is limited by the missile modal properties. The lowest allowable missile system frequency is 10.5 Hz. Payload mass properties, stiffness, and location determine the effect of the payload on the system frequencies. These properties will vary greatly for each flight. For design purposes, the following requirements were developed based on a single centered payload. These are to be applied to all payload designs. For a multiple payload configuration, these requirements apply to each payload. The payload mass property data is characterized by a single variable, which is the CG location measured from the payload plate (MS 148.74). For a chosen payload CG location, the design curves presented in Figures 5.5-2 and 5.5-3 show the minimum allowable payload bending frequency to insure the all-up missile bending frequency is greater than 10.5 Hz. These data are shown for payload weights of 375 and 750 lb, respectively. The requirements on the lowest payload bending frequency for various combinations of weight and CG location are given in Table 5.5-1.

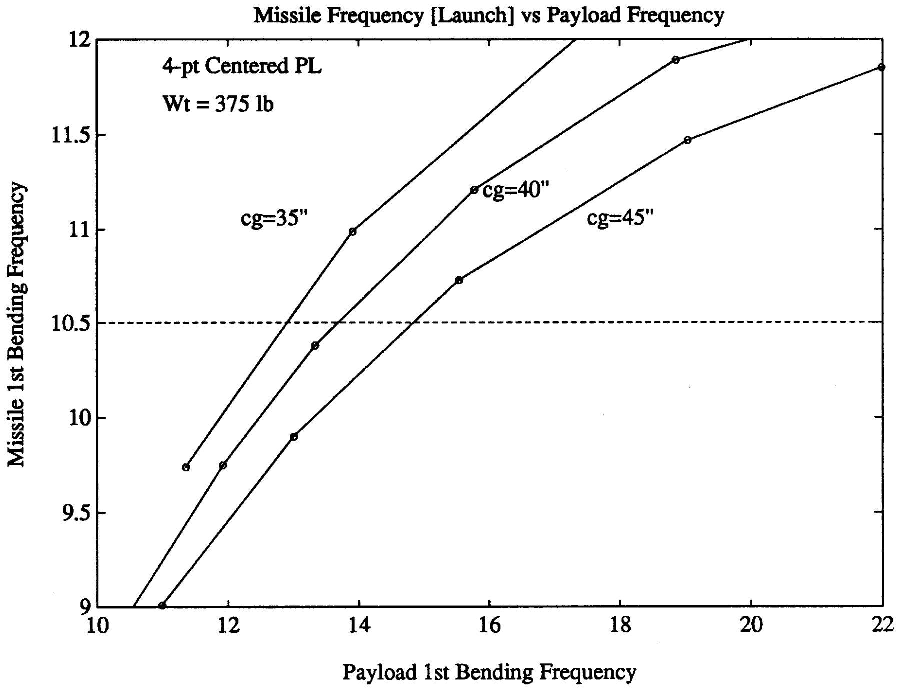

Figure 5.5-2 Lowest Allowable Cantilevered Payload Bending Frequency versus CG Location for a 375 Pound Payload

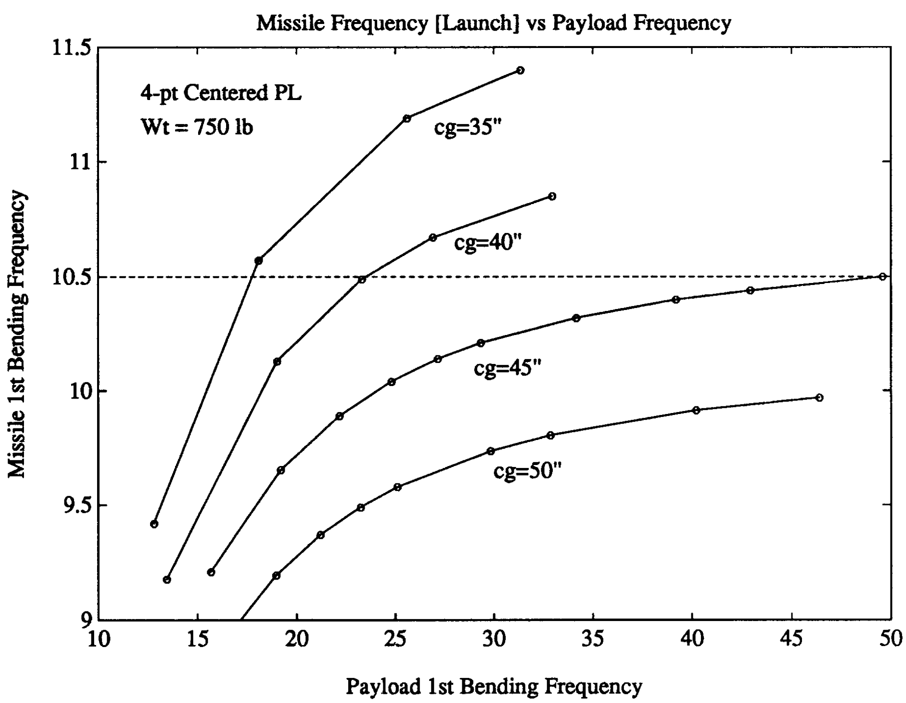

Figure 5.5-3 Lowest Allowable Cantilevered Payload Bending Frequency versus CG Location for a 750 Pound Payload

Table 5.5-1. Payload Minimum Allowable Bending Frequencies

Payload Weight (Lb)	CG Location (In Forward of Payload Plate)	Minimum Bending Frequency (Hz)
0 - 375	0 < Xcg < 35	13
	35 < Xcg <40	14
	40 < Xcg < 45	15
	Xcg > 45	Contact SNL
376 - 750	0 < Xcg < 35	18
	35 < Xcg <40	24
	40 < Xcg < 45	50
	Xcg > 45	Contact SNL

5.5.2.2 Payload Modal Test

A modal test is required for each payload. This test must simulate the fixed boundary condition (cantilevered) that will occur at the payload plate interface. The test must include the actual hardware or suitable mock-ups which exhibit all of the important properties including mass, stiffness, and damping. Detailed attachment components must be in-cluded in this test. Mode frequencies and shapes are required for all modes up to 128 Hz. If no modes are expected below 128 Hz, the test is still required for verification. The data must be delivered to the SNL Large Rocket Systems Department 9825 at least nine months before the scheduled flight.

Ideally, the payload dynamics should exhibit the following two characteristics:

1. Linearity
2. Repeatability

The natural frequencies of the payload should not vary markedly with the vibration amplitude. Likewise, the frequencies should not vary widely from assembly to assembly. If significant non-symmetries (i.e., non-orthogonal modes) exist, the payload orientation must be carefully noted to insure repeatability. Additionally, every effort should be made to minimize noise sources such as rattling due to loose components. Behavior affecting the above features is typically exhibited by a weak design in the payload attachment components. SNL is capable of working with any potential designer to help insure their payload design is flight worthy. Assistance can be provided in the development and implementation of modal test plans. Specialized structural dynamic test equipment is available, if required.

5.5.2.3 Analytical Payload Model

A detailed analystical model is required for any payload possessing at least one mode below 100 Hz. It must be delivered to the Large Rocket System Department 9825 at SNL at least nine months before the scheduled flight date. This report should include:

1. A payload model description, including figures.
2. Complete payload modal characteristics including mass properties, frequencies, and mode shapes.
3. A comparison of the model results with the modal test results.
4. A complete description of the formatted ASCII files containing the model data.

The model provided is preferably a NASTRAN finite element model (FEM). If this is not possible, a component mode synthesis (CMS) model may be provided. The requirements for each of these two types of models are included in the following sections. The accept-ance of the analytical model is subject to the approval of the structural dynamics depart-ment at SNL. In either case, the model must be correlated to the modal test data re-quested in Section 5.5.2.2. The correlated model is referred to as the test-verified model.

Test-Verified FEM

This is the preferred format. The model must be in terms of a formatted ASCII NASTRAN bulk data file. Allowable element types are CBAR, CBEAM, CELAS, CONM2, CQUAD, CHEX, RBAR, RBE2, and RBE3[7]. The use of a local or displacement coordinate systems should be avoided. The preferred coordinate system is the missile coordinate system that was defined in Section 1.4.6. In this system, the coordinates for the center of the payload plate forward surface are (-148.74, 0, 0).

Test-Verified CMS Model

If a NASTRAN model cannot be provided, a component modal model may be used. The necessary data requirements are specified in the CMS write-up in Appendix B. These data should be transmitted in ASCII format. For the analysis report, the organization of the data on the file along with a detailed account of the formats used to write the data is required.

The STARS payload designers should contact SNL to obtain the specifics for completing the exchange of the requested data. SNL can generate and analyze the finite element model if required by the payload designers.

5.5.2.4 Payload Design Modifications

Any payload design modifications which potentially affect the above data and occur after the data have been provided to SNL must be approved. A change in the payload struc

[7] MacNeal-Schwendler Corporation, *MSC/NASTRAN User's Manual, Volume I*, August 1991.

tural dynamic characteristics may require a repetition of all or parts of Sections 5.4.1 and/or 5.4.3.

5.5.2.5 Configuration Modal Tests

A configuration modal test consisting of the dodecagon and payload plate assembly, with actual or mock-up hardware representing a single payload, or each payload in a multiple payload configuration, is required. This test validates the dynamic behavior of the payload attachment to the missile. It must be completed nine months before the scheduled flight date. Arrangements must be made for the actual hardware acquisition or the construction of suitable mock-ups.

5.6 PAYLOAD CONTAMINATION

5.6.1 Third Stage Retro Motors

The third stage utilizes retro motors to increase the separation between itself and the separated payloads. Once all payloads are released, the ACS reorients the TS to minimize retro motor plume effects on the payloads. Then, at a set time after payload separation, up to four retro motors located on the payload plate are fired. The number of retro mo-tors and the exact time of ignition are determined by mission requirements. Since the third stage is generally oriented to an attitude different than that of the payloads, minimal contamination from the exhaust plumes is expected. Table 5.6-1 lists the major constituents of the retro motor exhaust. Full motor burn time is approximately one second.

Table 5.6-1 Third Stage Retro Motor Exhaust Products

Component	**Mole % @ 14.7 psia**
Al_2O_3	0.377
CO	0.299
CO_2	0.039
H	0.001
H_2	0.014
H_2O	0.113
HCl	0.056
N_2	0.101

5.6.2 Third Stage Motor

The third stage motor is fired after NF separation. The Orbus 1 motor is not equipped with thrust termination (not to be confused with a FTS). No payload contamination from the motor exhaust plume is expected. Table 5.6-2 lists the major constituents of the Orbus 1 motor exhaust. The full motor burn time is approximately 40 seconds.

Table 5.6-2 Orbus 1 Motor Exhaust Products

Component	Weight % @ 14.7 psia
Al_2O_3	37.77
Cl	0.05
CO	22.63
CO_2	2.20
H_2	2.31
H_2O	5.51
HCl	17.92
N_2	11.54
Other	0.07

5.6.3 Attitude Control System

The ACS utilizes a clean nitrogen gas system as the propellant. Expelled nitrogen from the ACS thrusters is not a potential contamination source for the payload.

5.7 REENTRY DEBRIS

Following the third stage retro firing, the third stage and the remaining hardware mounted on it will have to reenter. In doing so, it will produce additional targets and debris that could confuse the sensor(s) involved in supporting the mission. This section is included in the handbook to attempt to describe the breakup of the third stage and to delineate those pieces that are expected to survive the reentry.

The analysis that describes the breakup was completed by SNL. The analysis shows the third stage will breakup into the six components shown in Table 5.7-1.

Table 5.7-1 Third Stage Reentry Debris

Item	Weight (Lb)	Length (In)	Diameter (In)
Antenna Shield	6.5		
Equipment Section Ring	117.2	18.0	54.0
Payload Plate & Release Hardware	89.5		
Third Stage Plume Heatshield	22.3		
Dodecagon	274.5	24.5	29.0
Expended Third Stage Motor	115.7	32.5	27.4

For a typical trajectory (~18000 ft/sec reentry velocity), this breakup is expected to occur near an altitude of 170 kft (52 km). Components mounted in boxes on the outside of the dodecagon will begin to break off once the vehicle starts its demise. The heating rates are sufficiently high to cause the antenna shield, the dodecagon, the payload plate, the third stage plume heatshield, and most of the component boxes to burn up completely. The demise of all of these pieces is predicted to occur before they reach an altitude of 100 kft (30 km).

The remaining pieces are the expended third stage motor, the equipment section ring, and possibly the IMU that had been mounted on the dodecagon. The large mass of these pieces coupled with the tumbling motion they are expected to experience will average out the reentry aerodynamic heating pulse. They are expected to survive until impact.

For each mission, a trajectory for the third stage, including the effect of the retro firing, will be provided to the experimenter. This trajectory will assume the third stage remains intact and survives to impact. If the experimenter(s) feels a more detailed analysis is required to insure mission success, they should contact the Strategic Targets Product Office to request this analysis.

6. MISSILE INSTRUMENTATION

This section describes the STARS I missile instrumentation capabilities that are available for the transmission of a limited amount of payload flight data via the TM system.

6.1 INSTRUMENTATION SUBSYSTEM

The STARS I instrumentation is designed to transmit booster system data. A limited amount of payload flight data may also be transmitted by the TM system.

6.1.1 Telemetry System

The STARS I TM system is used to monitor transducer output, critical missile voltages, and discretes of the missile and the payload(s). After the data signals have been conditioned, dual Pulse Code Modulation (PCM) encoders sample and digitally encode the data. The output of each encoder is used to modulate its dedicated S-band transmitter. This output may be encrypted prior to transmission, as required by the security classifcation of the data. In general, both links (known as Link A and Link B) contain identical information, since the data signal inputs are split in a TM junction box. Thus, a complete set of data signals is input into each encoder. The exceptions, high sample rate shock and vibration measurement signals, are sent directly to the encoders via the signal conditioner, bypassing the TM junction box. Missile guidance and navigation data are transmitted to the dual PCM encoders via a 1553B data bus. Figure 6.1-1 shows a block diagram of the STARS I telemetry system.
The PCM bit rate is 1,216,512 bits per second. The coding is NRZ-L. The format is IRIG

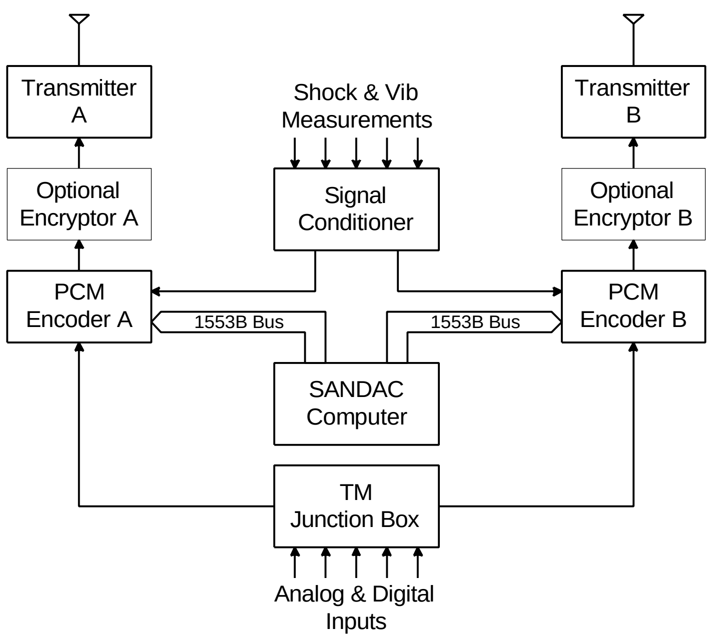

Figure 6.1-1 STARS I Telemetry System Block Diagram

compatible. Frame sync is accomplished using a 33 bit fixed pattern frame sync word of positive polarity, located at frame words 509 through 512.

Major frames consist of 16 complete minor frames with subframe identifier (SFID) values ranging from 0 through 15 (the count is up). The minor frames are identified by a SFID located in each frame at word 001. Word 001 is the first word following the frame sync pattern. The SFID word consists of nine (9) bits and no parity bit. Only the four (4) least significant bits (LSBs) of the nine (9) SFID bits determine the count. The remaining bits are zeros (0). The LSB is right justified.

There are 512 words per frame and 4608 bits per frame. Words 001, 509, 510, 511, and 512 are each composed of nine (9) bits with no parity bit. All other words consist of eight (8) data bits and one (1) parity bit which is the LSB. The parity is odd.

The TM channel characteristics are described in Table 6.1-1.

Table 6.1-1 STARS I Telemetry Channel Characteristics

Input Type		**Input Signal Range**
BiPolar (BP)	Analog	-5 V to +5 V zero bias
LoLevel (LL)	Analog	0 mV to +20 mV
HiLevel (HL)	Analog	0 V to +5 V
BiLevel (BL)	Digital	0 V to +5 V Logic 0: 0 V to 1 V Logic 1: 2 V to 5 V

The BP and LL inputs are double ended, while those of the BL and HL are single ended. The analog measurements are digitized with eight (8) bit, full scale resolution.

The telemetered missile data is made up in part of the following information:

- A & F commands and det fire indicators
- Shock accelerometer measurements
- Vibration accelerometer measurements
- Temperature measurements
- Pressure transducer measurements
- Critical missile voltages
- 1553B data (NG&C)
- Actuator command and feedback signals

The issuance of all payload discrete signals is verified by PCM instrumentation.

The STARS I vehicle attitude and rate data during the flight sequence are input via the 1553B data stream. These data can be used to determine the payload attitude at deployment. A summary of information available to payloaders from the STARS TM stream can be found in Appendix C.

6.1.2 Payload/Telemetry Interface

The STARS I TM system has a number of spare telemetry channels that may be used to monitor payload functions. The channels vary as to type, sample rate, and accessibility, and are divided into two categories: Category A and Category B. The section on the Electrical Interface (Section 4.) describes the connectors available for payload usage and the interface parameters and requirements. The payload designer must request use of the spare STARS I TM channels.

Category A channels are associated with dedicated cables and connectors, and are distinct from those of the baseline STARS I cabling system. These channels are generally available for payload use. A request to use Category A channels must be received by SNL at least 9 months before the scheduled flight date. It is recommended that the payload designer adopt Category A channels wherever possible, to reduce the impact and cost of customizing the STARS I cabling for Category B channel usage. Table 6.1-2 lists the types and quantities of Category A channels that are available.

Table 6.1-2 STARS I Category A Channels Available for Payload Use

Input Type	Number of Channels Available	Sample Rate (SPS)
LL	11	264
	19	33
HL	9	264
	3	132
	5	66
	13	33
BL	44	1056
	16	264

The Category B channels may or may not be available for payload TM, depending upon program considerations. These channels are closely associated with the baseline STARS I cabling system. SNL must receive a request to use Category B channels 12 months before the scheduled flight date. The types and quantities of Category B channels are listed in Table 6.1-3.

Table 6.1-3 STARS I Category B Channels Available for Payload Use

Input Type	Number of Channels Available	Sample Rate (SPS)
BP	13	264
LL	3	264
	1	33
HL	3	264
BL	2	528
	2	264

Since the STARS missile uses two identical encoders, there is a set of Category A channels associated with Encoder A and a set for Encoder B. Similarly, this applies to the Category B channels. Different sets of data may be input directly into Encoders A and B, bypassing the TM junction box. This doubles the number of channels listed in Tables 6.1-2 and 6.1-3. To a limited extent, the payload designer may possibly supercommutate a measurement by the use of multiple inputs for a given parameter. Subcommutation, using one or more of the channels, is possible.

6.2 PAYLOAD RF TRANSMISSIONS

The capability exists at the KTF LOB to receive, record, and playback RF transmissions from the payload(s) during the payload assembly process and prelaunch checkout.

6.3 PAYLOAD RF FREQUENCIES

Careful attention must be given to the choice of S-band frequencies for payload TM. The missile/payload RF subsystem must be designed to minimize the effects of inter-frequency modulation.

The RF frequencies, with their usage, for the STARS I missile are shown in Table 6.3-1.

Table 6.3-1 STARS I Missile Frequencies

Link Description	Frequency (MHz)	Emission Characteristics (Type/Bandwidth/Max Pwr)	Usage
C-Band Down Link	5690.0	Pulse/11 MHZ/800 W peak 9μsec double pulse spacing	Range Safety
C-Band Up Link	5620.0	N/A	Range Safety
GPS L1	1575.42	N/A	Navigation & Guidance
GPS L2	1227.60	N/A	Navigation & Guidance
Telemetry Link A	2263.5	PCM-FM/1.2 MHz/20 W cw	S-Band PCM Telemetry
Telemetry Link B	2250.5	PCM-FM/1.2 MHz/20 W cw	S-Band PCM Telemetry
UHF Cmd Destruct A	407.0	N/A	Range Safety
UHF Cmd Destruct B	407.0	N/A	Range Safety

6.4 LIGHT WEIGHT INSTRUMENTATION SYSTEM (LWIS)

The LWIS can be used to measure the motion and environment of light weight RV targets. The system is built in a distributed form and weighs less than 1.3 kilograms. It consists of two major sections:

1. A nose electronics unit capable of motion measurements, control, and digitization.
2. An aft electronics unit capable of environmental measurements, with power conditioning, an experiment control fireset, and a battery.

The LWIS contains a small programmable, Actel gte-array based, state machine which measures 58 channels of sensor and status data using a 12 bit A/D converter. The data output is transmitted as a 16,000 bit per second bi-phase PCM serial stream using a 150 milliwatt S-band transmitter. The data may be encrypted prior to transmission. Typically, data streams from the RV targets are received at the bus vehicle. Each data stream is then input into its own dedicated Voltage Controlled Oscillator (VCO). The VCO outputs modulate a high power S-band transmitter for retransmission to the ground.

The LWIS is capable of making the following types of measurements:

- horizon position using infrared sensors
- 3-axis roll rates
- 3-axis vehicle orientation with respect to earth's magnetic field
- axial acceleration (dynamic range of 100 microg to 75 g)

- up to 40 body internal and external temperatures using a combination of IC sensors, thermocouples, and resistance temperature devices
- internal pressure
- battery voltage
- fireset diagnostic voltages
- power supply monitor voltages

All current applications utilize a common design with common sensors and electronics boards. Different board layouts must be used in some applications to meet space and size constraints. The LWIS has currently been adapted for use on four different types of vehicles:

- Rigid light RV replica
- Canisterized light RV replica
- Canisterized traffic balloon
- Inflatable light RV replica

The first LWIS flight unit was successfully flown on the Countermeasures Demonstration Experiment (CDX) flight out of KTF on May 5, 1992. Requests to utilize the LWIS should be directed to the Strategic Targets Product Office at USASSDC.

7. STARS LAUNCH COMPLEX

7.1 FACILITY DESCRIPTION

The Kauai Test Facility is operated by SNL for the DOE. It provides a modern, integrated facility for conducting a wide range of test operations. These operations support R&D testing of materials, components, sensors, and advanced RV technologies. The facility has the infrastructure in place that provides the capability to conduct rocket borne experiments in the upper atmosphere, the ionosphere, or in space. KTF is responsible for the coordination of all launch activities concerning the STARS I booster system.

KTF, as shown in Figure 7.1-1, is located as a tenant on the northern end of PMRF at Barking Sands, Kauai, Hawaii. PMRF, located on the westernmost side of Kauai, is approximately 37 road miles from the commercial airport at Lihue.

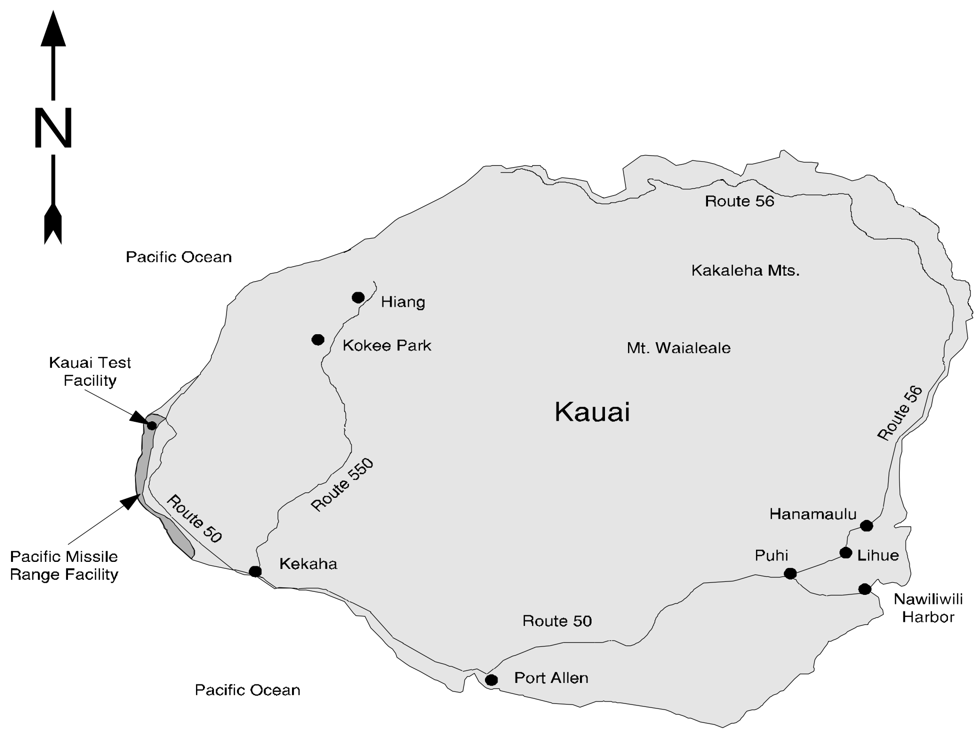

Figure 7.1-1 Location Map of the Pacific Missile Range Facility and the Kauai Test Facility Located on Kauai, Hawaii

Resources are available at KTF for assembling, testing, launching, tracking, and recover-ing instrumented rockets, rocket payloads, and aircraft payloads. A modern TM receiving station has the capability for making high quality recordings, and for providing quick-look playbacks of radio telemetered test data. In addition, resources are available for obtaining optical and photometrics coverage of test objects and experiments. Several rail launchers are in place for launching smaller rocket systems. Figure 7.1-2 shows the KTF Site Map.

Several facilities and resources are available to support rocket operations, including the Missile Service Tower (MST), the Missile Assembly Building (MAB), the Launch Operations Building (LOB), several assembly buildings, and associated ancillary equipment (tugs, manlifts, stake truck, etc.). Limited office space is also available. KTF can support up to twenty payload designer personnel per mission. This is a total mission quantity, not an individual agency value. Details on access to the facilities and/or particulars regarding operations at KTF are available from SNL.

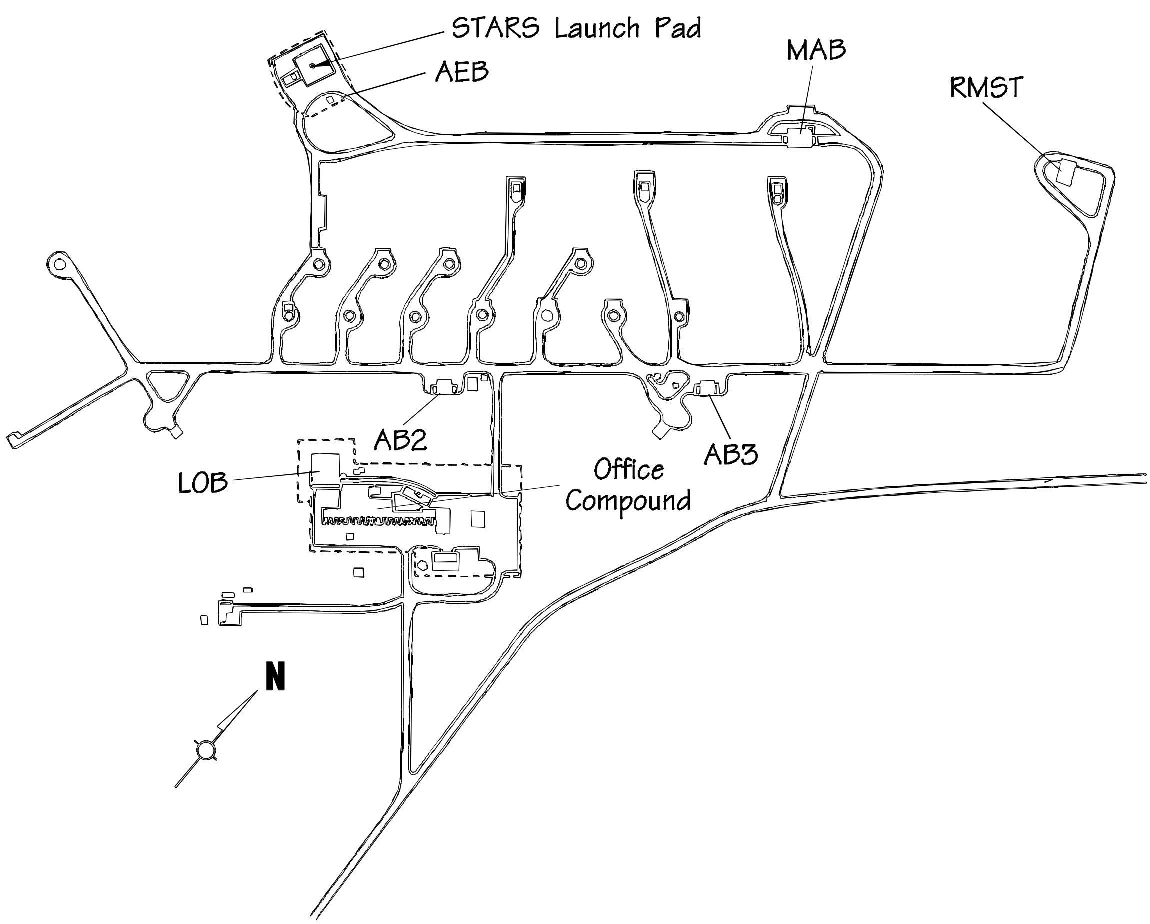

Figure 7.1-2 Kauai Test Facility Site Map

7.1.1 Missile Service Tower

The MST is an enclosed 16 ft-long by 16 ft-wide by 54 ft-high, steel framed, metal panel, mobile tower, located at KTF Pad 42 (STARS Pad). The pad area is shown in Figures 7.1-3 and 7.1-4. The main compound at KTF can be seen in the background in Figure 7.1-4. Figure 7.1-5 shows a layout of the MST. The MST has sliding doors that open to allow the MST to be rolled into place around the STARS missile after the missile has been uploaded onto the launch stand. The MST has interior floor levels at three different heights. These are located at 13 feet 6 inches, 22 feet 10 inches, and 31 feet 2 inches above the finish slab level. The tower is environmentally controlled to a nominal 76°F (±4°) and a 50% relative humidity by a 16-ton refrigeration unit. The MST is equipped with a one-ton monorail crane to aid with payload handling and integration. The rated interior floor live loads are 75 lb/ft^2 plus 2000 lb of concentrated load. The building is capable of operating in a classified secure mode. The allowable Net Explosive Weight (NEW) is 30,000 lb of Class 1.1 explosive.

Also located at Pad 42 is the concrete masonry Auxiliary Equipment Building (AEB). It has exterior dimensions of 11 feet 4 inches wide by 20 feet long and houses DC power supplies and associated electronic equipment used for missile and payload control and checkout. Umbilicals connected to the missile route the electrical status and missile control functions via the mast to the AEB.

Figure 7.1-3 STARS Launch Pad (Pad 42) Showing the STARS I Missile and the MST in the Retracted Position

Figure 7.1-4 Aerial View of the STARS Pad 42 Showing the STARS I Missile, the MST, and the AEB

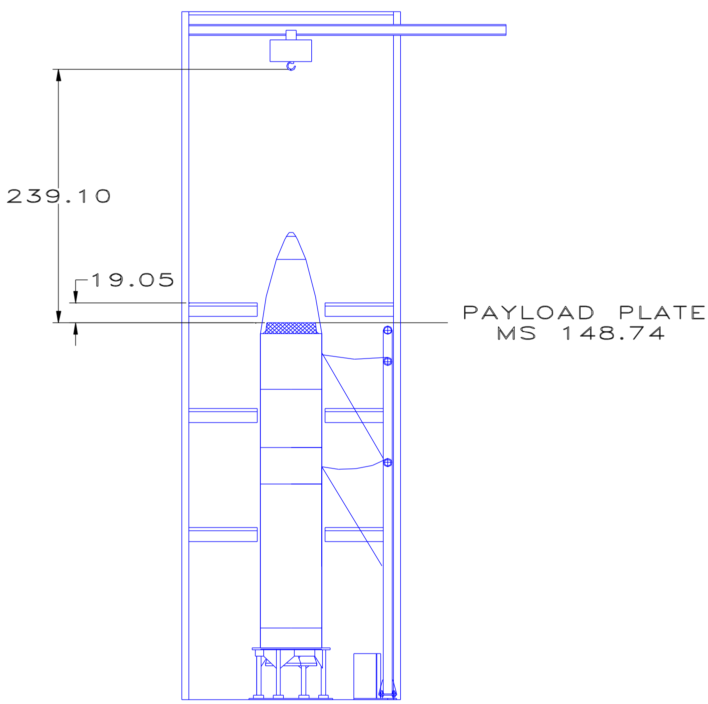

Figure 7.1-5 MST with the STARS I Missile Layout

Space has been allocated in the AEB for two standard size racks that can be used by the payload designers to mount test instrumentation. A standard rack is approximately 24 inches wide by 36 inches deep by 80 inches high. Refer to Section 4.3.1 for information on available payload electrical connections. This building is climatically controlled by a 6-ton refrigeration unit and is capable of operating in a classified secure mode.

The maximum number of personnel allowed in the pad area, which includes the MST and the AEB, is thirty. The designated safety officer, however, has the authority to restrict access as necessary.

7.1.2 Missile Assembly Buildings

The MAB is a 68 ft-long by 50 ft-wide by 27 ft-high pre-engineered, metal building with a 2400 ft2 high-bay area containing 10- and 20-ton overhead bridge cranes. The cranes have a hook height of approximately 17.5 feet. The balance of the facility provides office space and laboratory space for instrumentation calibration, assembly, and checkout of the missile electronics. This facility is shown in Figure 7.1-6. The MAB floor plan is presented in Figure 7.1-7. The MAB provides the staging and assembly area for the STARS rocket system components. It is not available for payload assembly or processing. Personnel responsible for the payloads will only be allowed access to the MAB if required for system tests and final vehicle integration. Special accommodations can be made if access to the high bay cranes is needed.

The high-bay is environmentally controlled to a nominal 76°F with 50% relative humidity by two 44-ton refrigeration units. The office and laboratory areas have individual air-conditioning systems. The building is capable of operating in a classified secure mode.

Figure 7.1-6 STARS Missile Exiting the MAB through the West Door

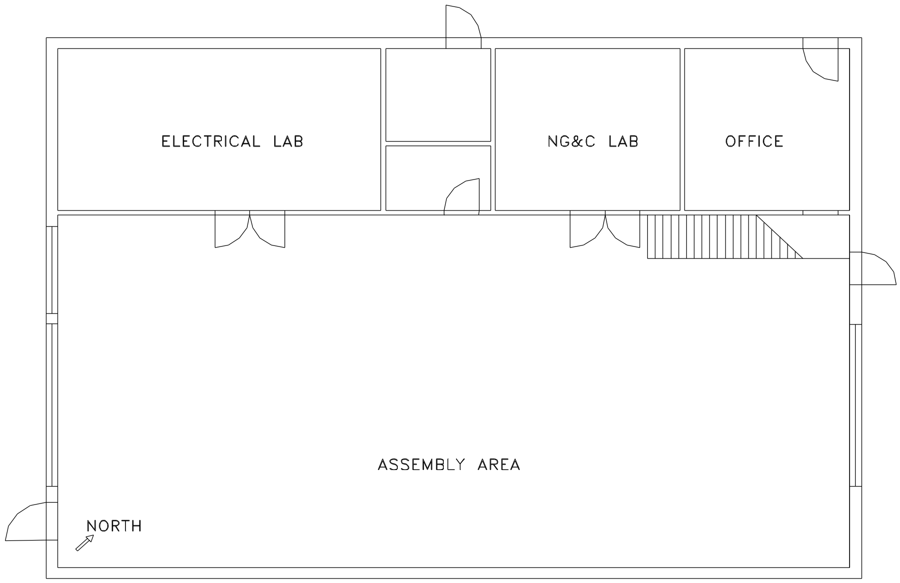

Figure 7.1-7 Floor Plan of the MAB

Two 15 foot doors on each side of the high bay allow vehicle access. The allowable NEW is 30,000 lb of Class 1.1 explosive. The maximum number of personnel allowed in the MAB during hazardous operations is thirty. This number may be reduced by the safety officer as deemed necessary for various operations.

Also available, is the Rocket Motor Staging Area (RMST). This is a revetted structure (40 feet by 80 feet) with openings on the sides for ventilation. The RMST can be used to assemble rocket motors. It is equipped with a four-ton bridge crane.

7.1.3 Assembly Buildings

Assembly Buildings 2 and 3 (AB2 & AB3), which are identical in size and construction, are 36 ft-wide by 38 ft-long wood frame structures with a corrugated aluminum roof and siding. AB3 can be seen in Figure 7.1-8. A layout of the buildings is presented in Figure 7.1-9. Each building is climatically controlled by a five-ton refrigeration unit. They each house a 29 feet by 35 feet work bay complete with benches, scales, and a grounding grid. Two monorails 12.5 feet apart span the length of each building. Each monorail has a two-ton and a three-ton chain hoist, with a hoist height of 10.5 feet. Rocket motors or payloads can be transported into and out of the building via two 93 inch wide by 92 inch high doors located at each end of the building. Each building also has a 8 ft-wide by 35 ft-long office area partitioned off of the work bay. These buildings are used to assemble and test payloads or small rocket assemblies. They are capable of operating in a classified se-cure mode. The allowable NEW for these buildings is 30,000 lb of Class 1.1 explosive. The maximum number of personnel allowed in AB2 or AB3 during operations is twelve, however this number may be further limited by the assigned safety engineer as deemed necessary.

Figure 7.1-8 KTF Assembly Building 3

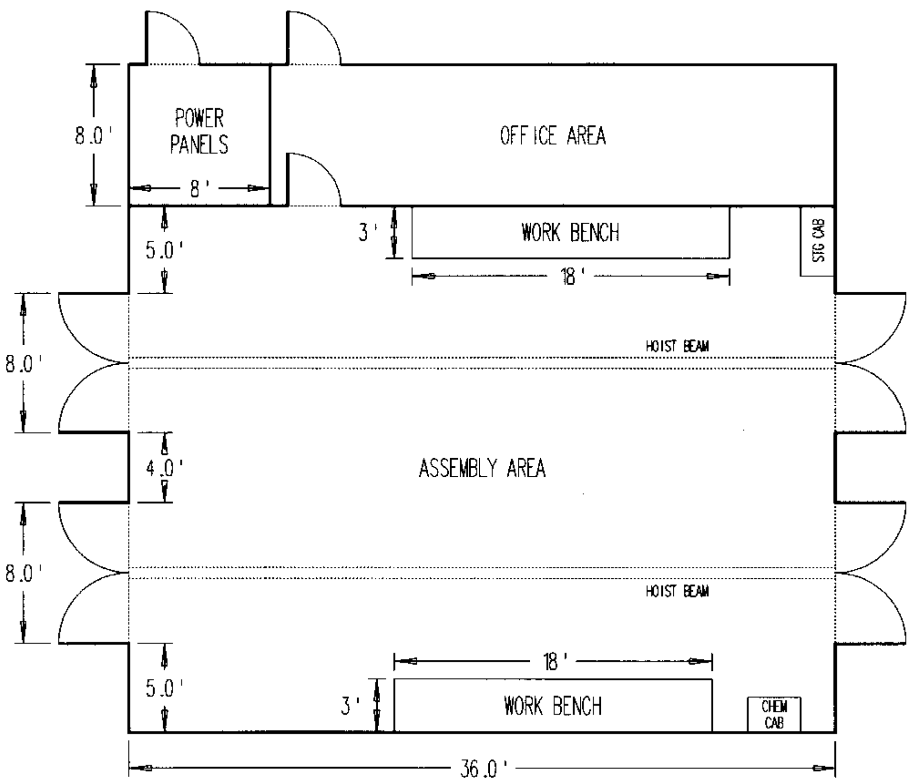

Figure 7.1-9 Assembly Building Layout

Also available for payload processing is a 40 ft-wide by 81 ft-long by 10 ft-high insulated wood frame structure clad with corrugated aluminum roofing and siding. This facility cannot process any hardware containing explosives. This climatically controlled facility is subdivided into three payload assembly areas (PLD A, B & C), and an area for storing electronic equipment and other miscellaneous hardware. These payload areas are primarily used to assemble and test nonexplosive payloads. They are also used for supporting other STARS ancillary systems such as the air monitoring system. PLD A is equipped with a one-ton electric hoist and a two-ton manual hoist. A 90 inch wide by 180 inch high door provides access to PLD A.

7.1.4 Launch Operations Building

The LOB is a 56 ft-wide by 74 ft-long by 10 ft-high earth covered, reinforced concrete structure. This facility is shown in Figure 7.1-10. It is the central facility for all aspects of the launch operations, the control and monitoring of launch facility functions, and the data gathering that occur at KTF. The hardened building houses the ground launch computers, the telemetry and recording station, the command transmitter, the TM antenna control, the command and control console, the missile NG&C monitoring system, the missile status and control system, the wind profiling computer, the payload integration and control consoles, and the range communication and video recording room. All missile and payload control functions at the STARS Pad 42 are performed from this building. Figure 7.1-11 shows a layout of the building. The LOB floor has a raised floor and has a designed loading of 100 lb/ft^2. Thirty-five operators and twelve casuals are permitted in the LOB during a launch operation.

Approximately 144 ft2 of floor space is available for the use by the payload designer(s) in the LOB. The possibility of joint occupancy by the payload designers must be considered. Electrical power is available for payload control and monitoring equipment. Landlines (50

Figure 7.1-10 KTF Launch Operations Building

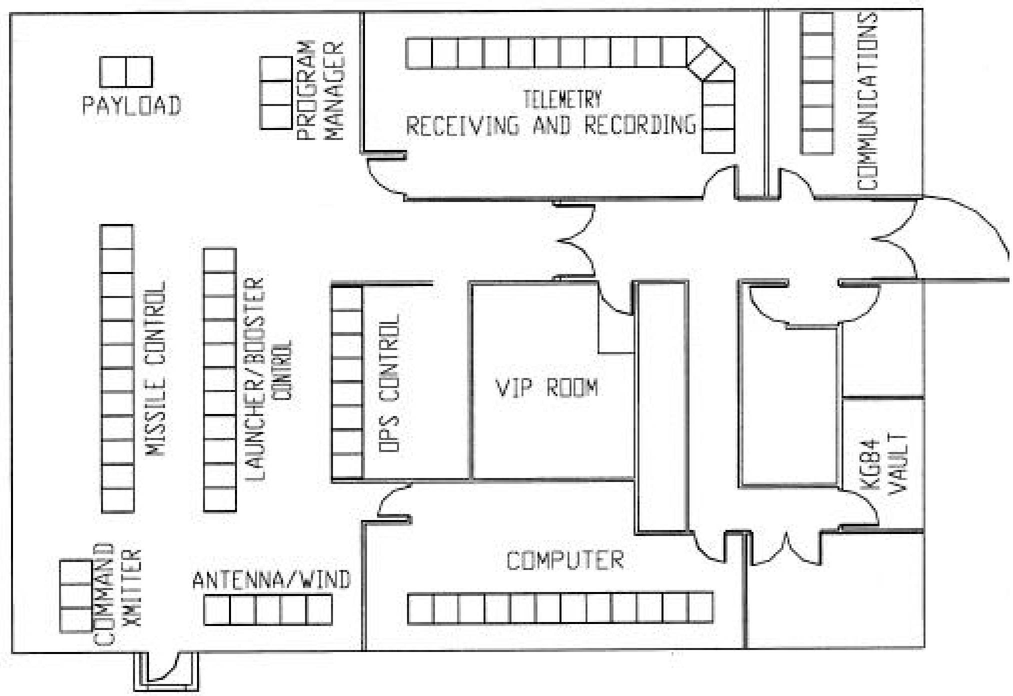

Figure 7.1-11 Floor Plan of the Launch Operation Building

pairs) that provide communication with the missile payload are terminated at the Payload Console. They provide patch-in capability to the payload so that once the STARS missile is on the pad, the payload(s) can be monitored and controlled from the Payload Console in the LOB. The landline electrical characteristics are described in Section 4.3.1. TM data from the missile is also available at thePayloader's Console. The Payloader's Console communication network consists of various intercom nets including the Countdown and Payload Nets, direct voice and radio nets, and access to commercial telephone lines. The dialog between KTF and PMRF range control can also be monitored. Video displays showing the outputs from various range cameras and the mission countdown are available at thePayloader's Console.

The building is capable of operating in a classified mode. A vault that can hold classified documents is located here. The highest level of classification is Secret.

1.1.1 General Facilities and Support Areas

Facilities and support area requirements (e.g. office space, transportation, test and maintenance areas, etc.) will be furnished by KTF as available and as negotiated with the payload designer.

Any special payload handling equipment or service facilities will have to be furnished by the payload designer.

7.2 KTF RANGE CAPABILITIES

Payload telemetry support is provided by the KTF TM ground station located in the LOB. It provides receiving, recording, real-time display and post-test playback of telemetry data. The station supports complete coverage of RF signals in the S-band (2200-2400 MHz) and P-band (225-260 MHz) TM bands.

Analog tape recorders can record either receiver Pre-D outputs or video outputs depending on the modulation format or the customer's requirements. A station FM multiplex containing reference frequencies, Inter-Range Instrumentation Group (IRIG)-B timing, receiver Automatic Gain Control (AGC) signals, and selected voice communication channels is also recorded.

PCM decommutation systems are available for real-time analysis and display or for post-test playback. Information needed for real-time go/no go decisions can be displayed in several ways. These include analog meters, oscillograph or strip chart records, oscilloscopes, spectrum analyzers, computer printouts, and alphanumeric and graphical displays.

Post-test quick look data can be supplied in the form of strip charts or oscillograph rec-ords. Any combination of PCM, Pulse Amplitude Modulation (PAM), and FM/FM data can be printed subject to the constraints of the number of channels, channel deflection desired, paper width, etc. A computer workstation is available for producing data listings and plots. Analog data tape dubs can be provided upon request.

A command/control/terminate system is available for supporting mission requirements. The FM transmitters are tunable over the 400 to 450 MHz range. They have adjustable output power up to 1000 W. A tone generator is available for generating standard IRIG control tones with a tone encoder.

7.2.1 Telemetry Data Reception

KTF utilizes three tracking antennas to provide complete coverage of RF signals in the S-band and P-band. These tracking antennas and their characteristics are:

1. 20 ft parabolic dish with:
    - Pre-amp coverage of the 2200-2400 MHz frequency range
    - System Gain/Temperature (G/T) = 12.25 dB/°K
    - Simultaneous Left Hand Circular (LHC) and Right Hand Circular (RHC) polarizations
    - Manual and slave modes of operation w/autotrack capability

2. 15 ft parabolic dish with:
   - Pre-amp coverage of the 2200-2300 MHz frequency range
   - System G/T = 11.15 dB/°K
   - Simultaneous LHC and RHC polarizations
   - Manual and slave modes of operation

3. P-band quad 'six-turn' helix antenna with:
   - Pre-amp coverage of the 225-265 MHz frequency range
   - Antenna gain = 19 dB
   - RHC polarization
   - Manual and slave modes of operation

KTF has 8 ea Microdyne Model 1400MR TM RF receivers, 6 ea Microdyne Model 1100AR TM RF receivers, and 7 ea Microdyne Model 3200 pre-detection diversity combiners. All receivers provide standard IRIG defined Intermediate Frequency (IF) bandwidths. The diversity combiners provide standard IRIG pre-detection frequencies of 225 to 2100 KHz. KG-66R decryptors are available to process encrypted TM signals.

7.2.2 Telemetry Data Recording

Two models of Ampex analog tape recorders are at KTF. The quantities and characteristics of each are in Table 7.2-1. Both models support the IRIG standards for 14 track recorders. They can be configured for direct recording and/or wide band group II FM recording. Station status consisting of an IRIG-B timing signal, telemetry receiver AGC's, selected voice nets, and the standard reference frequencies of 100 and 200 KHz is recorded using a FM multiplexer.

Table 7.2-1 Analog Tape Recorder Characteristics

Model Number	Quantity	Frequency Response	Recording Speed
FR3030	4	4 MHz direct 1.0 MHz FM at 240 IPS	1 7/8 to 240 IPS
PR2230	4	2 MHz direct 500KHz FM at 120 IPS	1 7/8 to 120 IPS

7.2.3 Telemetry Data Analysis/Display

KTF supports IRIG Proportional Bandwidth (PBW) and Constant Bandwidth (CBW) FM subcarrier channels. The equipment used are 30 ea Metraplex model 100 FM channel selectors and 2 ea EMR model 410 tunable FM discriminators.

Support of standard IRIG PCM/PAM formats is provided by:

1. 2 ea Loral ADS100 PCM decommutation systems with:
   - 8 Digital to Analog Converter (DAC) outputs per system
   - 16 bilevel outputs per system

2. 1 ea Veda series 30 PCM decommutation system with:
   - 16 channels of analog input
   - 16 bilevel inputs (discretes)
   - 32 DAC outputs
   - 2 internal PCM bit synchronizers (1K to 20 Mbit/sec)
   - 4 PCM decommutator boards (10 to 20 Mbit/sec)
   - 1 IRIG time code translation board
   - 2 front end data archive disks (1.0 Gbyte/ea)
   - 2 Silicon Graphics workstations for data display/analysis

3. 6 PCM Bit Synchronizers (bit rates up to 15 Mbit/sec)

TM data can be displayed on Honeywell model 1858 oscillographs, Astro-Med model MT8500R strip chart recorders or analog meters using FM subcarrier channel selectors.

7.2.4 Available Diagnostic Equipment

Available diagnostic equipment at KTF are:

- RF & baseband spectrum analyzers
- RF & audio frequency counters
- RF & audio signal generators
- Oscilloscopes
- Multimeters

7.2.5 Photometric Documentation

SNL Photometrics can provide photographic documentation of the rocket buildup and payload preparation using still photography and video. In addition, high-speed pin-registered cameras operating at 400 frames/second and rotating-prism cameras operating at speeds up to 10,000 frames/second are available to provide detailed photographic coverage of the rocket liftoff. Camera stations can be located as close as 60 feet or as far away as 6 miles from the launch pad. Photographic equipment available to cover rocket launches include:

- A 70mm high-speed pin-registered camera operating at 120 frames/second for high-resolution coverage of the launch event.
- A SNL designed time-lapse camera with a 76° x 98° field of view on a 5 x 7 inch format for coverage of the overall launch trajectory.

- The ME16 tracking telescope with a 117.5-inch focal length lens for detailed records of flight performance using a 35mm high-speed camera or high-speed video.

There are also various intensified film and video, time-lapse, and infrared imaging cameras available for coverage of upper atmospheric effects experiments.

7.3 KTF GROUND SUPPORT EQUIPMENT

The support equipment available at KTF is listed in Table 7.3-1. If required, a payload designer can request the use of this equipment on a non-interference basis with other scheduled range activities.

Table 7.3-1 KTF Ground Support Equipment

Air-Log 6200 Loading Trailer A:	Load Capacity 15,000 lb
Air-Log 6200 Loading Trailer B:	Load Capacity 15,000 lb
Air-Log 4100 Loading Trailer A:	Load Capacity 15,000 lb
Air-Log 4100 Loading Trailer B:	Load Capacity 15,000 lb
Air-Log 3000 Motor Transport Trailer (10 ea):	Load Capacity 15,000 lb
STARS First Stage Dolly	
STARS Second Stage Dolly	
Forklift A (Hyster 10 ton):	Lift Height 146.5 in
Forklift B (Caterpillar 4 ton, All Terrain):	Lift Height 192.5 in; DR 355 in
Forklift C (Hyster 3 ton):	Lift Height 124.5 in
Forklift D (Caterpillar 2 ton):	Lift Height 130.0 in; DR 173 in
Tug A (8000 lb Draw Bar Pull)	
Tug B (8000 lb Draw Bar Pull)	
Tug C (4000 lb Draw Bar Pull)	
Manlift (42 ft Height, 1500 lb Platform Capacity)	
Cherry-Picker (60 ft Reach, 600 lb Bucket Capacity)	
Forklift Work Platform (6x12 Aluminum Platform for 4 ton Forklift)	
Forklift Work Platform (4x5 Aluminum Platform for 3 & 4 ton Forklifts)	
Air Compressor A (Portable Diesel, 250 CFM)	
Air Compressor B (Portable Diesel, 250 CFM)	
Nitrogen Pressurization Cart (6000 psi Working Pressure, 10000 psi Proof Tested)	
RMSA Bridge Crane (Electric, 4 ton, HH 13′ 3″)	
AB2 Monorail Hoists (Manual, 3T/2T, HH 9′ 10″/10′ 2″, South Bay, 3T Rail)	
AB2 Monorail Hoists (Manual, 3T/2T, HH 9′ 10″/10′ 2″, North Bay, 3T Rail)	
AB3 Monorail Hoists (Manual, 3T/2T, HH 9′ 10″/10′ 2″, South Bay, 3T Rail)	
AB3 Monorail Hoists (Manual, 3T/2T, HH 9′ 10″/10′ 2″, North Bay, 3T Rail)	
AB6 Bridge Crane (Electric, 20 ton, HH 17′ 7″)	
AB6 Bridge Crane (Electric, 10 ton, HH 17′ 11″)	
Pad 42 MST Hoist (Monorail, Electric, 1 ton, HH 49′ 6″)	
PLD A Hoists (Monorail; Electric, 1 ton; Manual, 2 ton, HH both 13′ 9″)	
Stake Truck (5 ton, 1 ton Electric Lift Gate)	
Balance Facility Hoist (Monorail, Manual, 2 ton, HH 15′ 5″ to Table Surface)	
Welders	
Machine Shop	

There is also a 10 foot by 12 foot by 8 foot high Class 1000 portable clean room available that can be assembled and installed in either AB2 or AB3. Setup time is approximately 24 hours.

7.4 PAYLOAD SUPPORT EQUIPMENT SPACE PROVISIONS

Space allocated for setting up the payload support equipment (SE) is available in the AEB as described in Section 7.1.1, and in the assembly buildings as described in Section 7.1.3. Payload simulators with related check-out boxes may be placed on the third level of the MST for umbilical cable checkout before the missile is moved to the pad. The space allocated for payload control and status equipment in the LOB is described in Section 7.1.4.

7.5 COMMUNICATIONS

The Kauai Test Facility supports the following communications equipment:

- Standard telephone service, both local and long distance.
- FAX machine.
- Electronic data transfer via modem.
- Two portable radio nets for inter-island communication.
- Two portable radio nets for intra-range communication.
- Programmable voice intercom system that can access the PMRF communications network, the telephone system, and the radio nets.
- Access to worldwide DoD Communication Network through PMRF.
- Access to E-mail through PMRF.

Telephone service, access to the FAX machine, modem, and a dedicated payload intercom net are standard communications that are available to all payload designers. The use of the radio nets and access to off-range networks (other than telephone) are limited by mis-sion requirements and availability.

8. PMRF LEAD RANGE SUPPORT

8.1 COORDINATION FUNCTION

PMRF is the lead test range for the STARS launch operations. They are responsible for all flight safety decisions, and for the coordination of all range and inter-range activities during the prelaunch, launch, and in-flight phases of the mission. They will coordinate all requirements with Naval Air Warfare Center Weapons Division (NAWCWPNS), Detachment 2 Space and Missile Systems (DET 2 SMC), 30th Range Squadron (30 RANS), Wheeler Network Communications Center (WNCC), KTF, KMR, and other government agencies that are involved in supporting the mission.

8.2 PMRF RANGE INSTRUMENTATION

The *PMRF Range User's Handbook*[8] describes the capabilities of the range instrumenta-tion that is available to support the STARS missile launches from KTF. This section summarizes the information presented in this handbook.

The PMRF instrumentation measurement systems are capable of precision air and surface radar tracking, land based and airborne surface and air radar surveillance, and telemetry data recording and display. The PMRF measurement systems are capable of supporting target and weapon tests throughout a 1,000 square mile range area, simultaneously monitoring events in both the surface and air environments.

8.2.1 PMRF Radar Systems

There are eight long range, high accuracy radars for tracking, real-time display, and data recording of ships, aircraft, weapons, and ballistic missiles. Four of these are the AN/MPS-25 radars. Two are located at Barking Sands, while the other two are posi-tioned on Makaha Ridge. There is one AN/FPS-16 radar at Kokee Park. The remaining three are AN/FPQ-10 radars. Two are located at Makaha Ridge and the third is at Kokee Park. These radars are used for system checkout of C-band transponders, as well as tracking of booster and payload(s) during the actual mission.

There are two AN/APS-134 (V) surface search radars. One is located on Makaha Ridge and the other is on Niihau Island located to the west of PMRF. An AN/FPQ-12 surface/air search Track While Scan (TWS) radar is also located on Makaha Ridge. The Barking Sands Operations Control Center has an AN/SPS-10 surface search radar. Radar data from the Hawaii Air National Guard (HIANG), AN/FPS-93A air search radar at Kokee is also transmitted to Barking Sands to support PMRF surveillance and control.

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[8] *PMRF Range User's Handbook*, September 1991.

Identification Friend or Foe (IFF) equipped radars are the AN/SPS-10 radar at Barking Sands, the AN/FPQ-12 radar at Makaha Ridge, and the HIANG Kokee AN/FPS-93A radar. IFF data from the Air Force ARSR-3 radar at Mt. Kaala, Oahu is also transmitted to Barking Sands for display.

Radar tracking, surveillance, IFF, and other measurement system data, including Navy Tactical Data System (NTDS), are introduced into the Automatic Precision IFF Surveillance System (APIS) data system in the Real Time Computer Center (RTCC). The data system furnishes best available tracking data to real time acquisition recording, display systems, and presentation monitors in the operation control rooms.

8.2.2 PMRF Telemetry Systems

PMRF has two TM facilities. They are located at Makaha Ridge in Building 725 at an elevation of 1800 feet and at Kokee Park, adjacent to the Radar Building, at an elevation of 3800 feet. Makaha Ridge has three, 30 foot diameter and two, eight foot automatic tracking antennas. There is one eight foot tracking antenna at Kokee Park.

The S, High L, L, and P TM bands can be received at Makaha Ridge. S-band TM can be received at Kokee Park. All IRIG channels can be recorded, played back, separated, and displayed. Real-Time and playback Doppler miss distance scoring systems are at Makaha Ridge. Secured circuits transmit voice and data from Makaha Ridge to the Operations Control Center at Barking Sands. Uncovered voice and data transmissions between Kokee and the Operations Control Center are through the microwave system.

A dual EMR/Loral System 90 TM data system located in the RTCC displays TM data parameters in graphic and tabular formats to test participants located in the Range Control and Tracking and Control (T&C) Alpha. These data can also be displayed in the T&C Bravo control room. The data formats are designed to display Range Safety and Range control parameters. TM data can also be separated out for flight data recording and for display to the target controllers located in the control rooms. The System 90 records TM data for playback through the display systems and generates data listings for post test analysis.

8.2.3 Photometric Documentation

PMRF can provide photographic documentation of the STARS launch in the form of still photographs and video tape.

8.2.3.1 Still Photographs

PMRF's photography lab has the capability to produce photographs in color or black and white, in various formats. The lab can process film for color or black and white prints, enlargements, transparencies, and slides. Sequence shots can be taken at four frames per second from ground and aerial locations.

8.2.3.2 Video Tactical Analysis and Critique System (VTACS)

The VTACS is available in each of the T&C rooms. It consists of a DCX-M3 Sony color video camera with remote zoom/focus and pan/tilt, a MM-20 TASCAM stereo audio mixer, a VCR, a 4 inch black and white and two 8 inch color monitors used by the operator, and a 19 inch color monitor. The camera system is centered on a selected tactical display screen and records the currently selected source. Sources available for display include the local special effects generator, Facility Control surveillance TV system video, and local program output with time and date superimposed. The output tapes can be used for documentary and debriefing purposes.

8.2.3.3 Video Recordings

PMRF's video production facility has the capability to record, edit, and produce video tapes of operations which occur at the range. Events are recorded using 3/4 inch format camcorders with gyroscopic lenses to minimize vibration. Taping can be done from ground locations and aerial platforms such as the UH-3A helicopters stationed at PMRF.

Video tapes may be available for distribution in one to five days, depending on length, quantity, and sophistication in VHS, Beta, or 3/4 inch format.

8.2.3.4 Intermediate Focal Length Optical Tracker (IFLOTS)

The IFLOTS is a mobile, trailer mounted tracking system intended primarily to track and record (photograph) missile and target launches from PMRF. The tracker is a self contained unit with its own power generator which gives it the flexibility to be positioned anywhere in the vicinity of PMRF.

The IFLOTS platform has two mounting arms capable of carrying up to 150 lb of equipment. Azimuth and elevation functions are electrically driven and manually controlled by the operator. IFLOTS may be configured with various combinations of film and video cameras, and lenses. An IRIG-B timing receiver has been integrated into the system. Its output is encodedand may be superimposed on film/video. IFLOTS is capable of trans-mitting real-time video provided it is within a 5 to 10 mile radius of PMRF with clear line-of-sight. A GPS receiver is used to accurately pinpoint its remote location.

System configurations are developed based on requirements defined in the mission specific UDS documentation.

8.3 LOGISTICS

PMRF utilizes the standard U.S. Navy supply system. Any unique payload requirements must be provided by the payload designer.

Equipment transported to PMRF can be brought in by several methods:

1. Military air directly to PMRF.
2. Commercial air to Lihue Airport and truck transport to PMRF.
3. Sea transport.

The runway on PMRF can support aircraft up to and including the C-5. Sea transport usually arrives at Nawiliwili Port in Lihue. In addition, there are also docking facilities available at Port Allen. The equipment must be transported by truck to PMRF after being unloaded from the ship. Some ordnance storage is available at Kamokala Caves under the jurisdiction of PMRF. Use of these caves must be requested from the PMRF Program Manager. Standard services provided by PMRF include visitor control, emergency services such as fire and medical, and food services.

8.3.1 Payload Transportation at PMRF

A standard flatbed truck or flatbed trailer will be used to transport the payload on PMRF between the airplane unloading area and KTF (a distance of about 2 miles). Neither the truck nor the flatbed trailer has any special suspension provisions; but the roadway is considered "well maintained" asphalt, and the speed is restricted to 20 MPH or less. Any special environmental controls required must be provided by the payload designer.

8.4 RANGE OPERATING CONTROL ROOMS

PMRF has two T&C rooms, T&C Alpha and T&C Bravo, a Range Facility Control Office (RFCO) room, and a Battle Management Interoperability Center (BMIC) in the Range Operations Center (ROC). There are operating console positions for the Operations Conductor (OC), Missile Flight Safety Officer (MFSO), and the payload designer in each T&C room.

In the past, T&C Alpha has been used as the primary control room for the STARS missions. T&C Bravo has been used to host personnel not directly involved with the launch operations, but who are involved in other aspects of the mission.

The OC is responsible for all activities in the control room. The OC has direct communication with the test participants, Range Control, and the Range Contractor Controller (RCC) representing the range Operations and Maintenance (O&M) contractor. The available MFSO and Range User console positions are used as needed.

Each T&C control room is provided with ground, radio, and underwater communications with the test participants and the instrumentation sites. Networks are hard-wired with through jacks that are under facility control. They can be altered by patching to uniquely configured communication networks to satisfy the mission requirements.

8.5 PMRF COMMUNICATIONS

PMRF ground and radio communications are described in the *PMRF Range User's Manual*.

The communication systems at PMRF are categorized as the Range Communication Systems (RCS) and Defense Communication Systems (DCS). The RCS systems are comprised of specialized telecommunications, radio, microwave, and underwater equipment to fulfill the range operational requirements. The RCS and DCS systems, although distinct from one another, are interconnected and inter-operable.

The telecommunication systems transmit voice and data electromagnetic signals between the different range sites and areas. Transmission media includes wire, radio, microwave and light. Microwave and satellite circuits are linked into NAWCWPNS and WNCC at Wheeler AFB, Oahu. Voice and data circuits through WNCC access the Mainland and the Western Pacific ranges.

Mobile radio nets are established at PMRF for operational, emergency services, and security purposes. Base stations provide mobile radio coverage throughout Barking Sands and Makaha Ridge. A limited number of mobile radios are available for range users. The payload designer’s mobile radio requirements should be included in the UDS documentation described in Section 10.2.3.1.

Payload designers operating radio equipment on PMRF are cautioned that there are Hazardous Electromagnetic Radiations to Ordnance areas within Barking Sands. Payload designers must comply with PMRF electromagnetic radiation instructions.

The DCS systems provide communications with government agencies and commercial businesses. The equipment is principally commercial and subject to deregulation and competition. The DCS consists of an administrative telephone system and two satellite trunks that tie the telephone system into NAWCWPNS and the Oahu Telephone System, respectively. The later is subsequently tied into long haul commercial facilities including Automatic Digital Networks (AUTODIN).

Video Teleconferencing is available at PMRF through the Naval Warfare Assessment Center (NWAC), Defense Commercial Telecommunications Network (DCTN). A dedicated T-1 circuit links PMRF to the DCTN node at Corona, California. Programs requiring display of PMRF mission video must have access to a DCTN node. PMRF schedules its DCTN link for use as required for a mission with NWAC. The program office is responsible for scheduling all user DCTN nodes (facilities), including NWAC Corona, to receive source video from PMRF. Video encryption and full Video Teleconferencing will be available by the 3rd quarter FY95.

8.6 UPRANGE SENSOR CAPABILITY

In addition to PMRF assets, other uprange sensors are available to support user requirements. They include AMOS, AN/FPQ-14, and various mobile sensors. Uprange sensor requirements should be included in the UDS documentation described in Section 10.2.3.1.

8.6.1 AMOS

The Maui Space Surveillance Site (MSSS) is located on the island of Maui, Hawaii. The MSSS observatory contains the Air Force Maui Optical Station (AMOS), which provides measurement support to various government agencies and the scientific community, and the Maui Optical Tracking and Identification Facility (MOTIF), which is operated as a primary sensor of the USAF SPACETRACK network. The Ground-based Electro-Optical Deep Space Surveillance System (GEODSS) is a third facility at the MSSS.

The MSSS is a state-of-the-art electro-optical (E-O) facility which combines large aperture tracking optics with visible and Long Wavelength Infrared (LWIR) sensors to collect data on sub-orbital, near-earth, and deep space objects. The equipment at MSSS includes two 1.2 meter telescopes on a single mount; a 1.6 meter telescope; a 0.6 meter laser beam director; a 0.8 meter beam director/tracker; three acquisition telescopes; infrared sensors; low to moderate power lasers; conventional and contrast mode photometers; compensated and uncompensated imaging systems; Low Light Level TV (LLLTV) systems; video, alphanumeric, and graphic display equipment; and data processing systems.

Further information on the MSSS can be obtained from the *AMOS User's Manual*[9].

8.6.2 AN/FPQ-14

The AN/FPQ-14 radar is an on-axis, modified AN/TPQ-18 radar located at Kaena Point, Oahu. It is a C-band (5.4 - 5.9 GHz) Missile Precision Instrumentation Radar (MIPIR) Class radar, with an extended skin track capability that is achieved through the use of a pulse compression system. The FPQ-14 can also provide Range Vernier and Radar Cross Section data. This radar is under the cognizance of Vandenberg Air Force Base.

8.6.3 Hawaii Tracking Station

The Satellite Control Network (SCN) Hawaii Tracking Station (HTS) is located on Kaena Point, Oahu, Hawaii. The station consists of two Space Ground Link Subsystem (SGLS) Telemetry, Tracking, and Commanding (TT&C) antenna systems, designated HTS-A and HTS-B. The HTS-A antenna has a 60 ft dish while the HTS-B antenna has a 46 ft dish.
Both antenna systems are capable of receiving and recording multiple S-band (2.2-2.3 Ghz) TM signals. The capabilities of the antenna systems, as configured for the STARS program, are listed in Tables 8.6-1 and 8.6-2.

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[9] *AMOS User's Manual, Revision 9*, September 1990, Issued February 1992.

Table 8.6-1 HTS-A Antenna System Capabilities

Telemetry Downlinks	2 S-band, typically STARS Link-A and Link-B
Receiver Polarization	LHC and RHC, with diversity combiners providing a combined output for each signal
Data Recorders	HBR3000i 1 inch, 14 track, 9 channel instrumentation recorder FR-3030 1 inch, 14 track IRIG Group-III instrumentation recorder
Signals Recorded	Left-hand, Right-hand, and Combined signals, both pre- and post-detect for both downlinks, AGC for all receivers, and IRIG-B time

Table 8.6-2 HTS-B Antenna System Capabilities

Telemetry Downlinks	4 S-band
Receiver Polarization	RHC only
Data Recorders	HBR3000i 1 inch, 14 track, 9 channel instrumentation recorder
Signals Recorded	Flight dependent. Link-A and Link-B pre-detect downlinks plus one additional available on IRIG Group-III compatible data tracks. AGC and IRIG-B time is multiplexed and recorded on track 14.

NOTE: Only data recorded on tracks 10 and 14 of HBR3000i recorders is recoverable using a standard IRIG Group-III compatible playback unit. Track 13 contains error correction code and track 14 contains multiplexed AGC and IRIG.

Further information on HTS can be obtained in the *Air Force Satellite Control Network/Ground Interface*[10] document.

8.7 DOWNRANGE SENSOR CAPABILITY

After being launched from Kauai, the STARS missile is generally targeted to reenter in the vicinity of the KMR. KMR has many sophisticated sensors that are capable of recording radar tracking information as well as optical phenomena that occur during reentry. This instrumentation is available for supporting STARS tests when requested through the mission UDS documentation. The KMR capabilities are as outlined in the *KMR Range User's Manual*[11]. Refer to this manual and range points of contact for a description of current capabilities.

[10]TOR-0059 (6110-01) -3, *Air Force Satellite Control Network/Ground Interface*, March 1992.
[11]*KMR Range User's Manual*, May 1992.

8.8 MOBILE SENSORS

Other sensors may be requested by the payload designer to provide either uprange or downrange experiment coverage. These sensors include ARGUS, AST, Cobra Ball, Cobra Eye, Cobra Judy, HALO, and the U. S. Navy P-3 Cast Glance.

9. PRE-LAUNCH AND LAUNCH OPERATIONS

9.1 TRANSPORTATION

9.1.1 General

All items being shipped to KTF, whether the property of the DoD, the DOE, or a payload designer, are sponsored by the US Army, and are to be shipped in accordance with applicable regulations covering the movement of government cargo. Cargo may be received at Kauai and PMRF by either air or surface shipment. The PMRF airfield is capable of landing and off- loading all cargo aircraft, including the C-141 and C-5. Sea movement of equipment will come into Kauai at either Nawiliwili Port or Port Allen, then trucked to PMRF.

9.1.2 Movement Schedules

The equipment movement schedules are based on several factors, with the most important being the launch date. Other factors are the time required for equipment set-up and checkout prior to launch, and the mode of transportation selected. For preliminary planning, the majority of equipment and material will be required at PMRF/KTF by launch minus 30 days. The Military Sealift Command (MSC) and USAF Air Mobility Command (AMC) require an advance notice of 30 to 60 days prior to the shipment.

In moving equipment to PMRF, the range user must consider the following factors:

1. For sea shipment, the MSC requires items be at the port 7 to 10 days before sailing. These items should be shipped to the Oakland Army Terminal, Oakland, CA. Vessel information and the sailing date should be available from the Military Traffic Management Command (MTMC), Western Region, approximately 30 days before sailing. The transit time to Kauai is approximately 30 days.
2. Typically, for AMC shipments, items will be delivered to SNL shipping at least ten days prior to the shipment date. The AMC-SAAM (dedicated aircraft) will depart Albuquerque and fly to PMRF. The transit time to PMRF is usually one day. This shipment occurs approximately 30 days prior to the launch date.
3. When commercial transportation is used, the payload designer must make all of the necessary arrangements with the commercial shipper for delivery to PMRF.

9.1.3 Transportation Support Requests

The Strategic Targets Product Office will forecast all STARS shipping requirements (MTMC, AMC, or MSC). Requests for transportation support along with the necessary paperwork will be made by the agency/activity owning or controlling the items to be shipped. STARS project equipment and material transportation requests by STARS contractors will be handled in accordance with their individual contract's wording. In those cases where a contract specifies that equipment and material should be delivered "FOB Origin", requests for transportation should be processed through the local Defense Contract Management Command (DCMC) office for movement using the "Government Bill of Lading" (GBL, DD Form 1659). Where the contract specifies "FOB Destination", the contractor should make arrangements directly with commercial shippers for transportation to the final destination.

Requests for overseas shipping containers, such as the standard 20′ x 8′ x 8′ containers, should be made to the local transportation office or to the DCMC.

9.1.4 Shipment Responsibilities

The overall responsibility for the movement of all payload equipment and material to PMRF rests with the payload sponsor, who will provide direction, policy guidance, and funding. The shipment, including requests for transportation support, coordination, and paperwork, is the responsibility of the agency/activity owning or controlling the items to be shipped. Preparation for the shipment is the responsibility of the shipper and the local transportation officer. The applicable shipping regulations covering the mode of shipment, hazardous material, and security are listed in Table 9.1-1. Escorts required to accompany the equipment during transport because of security, safety, or other reasons are the re-sponsibility of shipper.

The following information must be provided for all shipments:

1. Item Name
2. Quantity
3. Length x Width x Height
4. Cube Feet of Item
5. Weight in Pounds of Item
6. Hazard Classification of Item
7. Security Classification of Item
8. Total Cubes of Shipment
9. Total Weight of Shipment
10. Date Required at PMRF

Table 9.1-1 Summary of Government Shipment Regulations

CATEGORY	REGULATION	TOPIC or TITLE
General	AFR 75-2/AR 55-355	Military Traffic Management Regulation
	AFR 76-38/AR 59-8	Military Airlift Requests
	AR 55-16	Movement of Cargo by Air and Surface
	AR 55-167	Movement of Cargo on Military Sea Transportation Service (MSTS) Vessels
	DoD 4500.32R	Military Standard Transportation and Movement Procedures (MILSTAMP)
Hazardous	49 CFR 100-199	Transportation-Movement of Hazardous Cargo
	AFR 71-4/TM 38-250	Packaging and Material Handling -- Preparation of Hazardous Material for Military Shipment
	DOT BOE 6000-H	Hazardous Materials Regulations of the Department of Transportation
Security	AR 380-55	Transportation of Classified Materials
Marking	Mil Standard 129	Military Marking for Shipment and Storage

9.2 STARS PROCESSING

The information presented in this section identifies the tasks required to build, test, and launch a STARS I vehicle and payload(s) from KTF. The process of systems/payload integration and testing will start at SNL in Albuquerque, New Mexico. STARS field processing will complete the activities necessary for launch. Appropriate assembly, test, and operating procedures shall apply.

9.2.1 Albuquerque Operations

The functions, presented as a processing flow diagram, are shown in Figure 9.2-1. This series of tests begins approximately 120 days before the scheduled flight date. These functions are as follows:

1. Third Stage Final Assembly - All nonhazardous, flight-qualified components, subsystems, and structural parts for the third stage are assembled into the TS flight structure at SNL.
2. Mass Properties Measurement - The gravimetric properties, including weight, center of gravity, and moments of inertia will be measured for the TS structure.
3. Electrical Systems Checks - Before and after environmental testing, electrical tests are conducted to verify subsystem functionality and total TS electrical system compatibility on both external and internal power. During this and all subsequent electri-

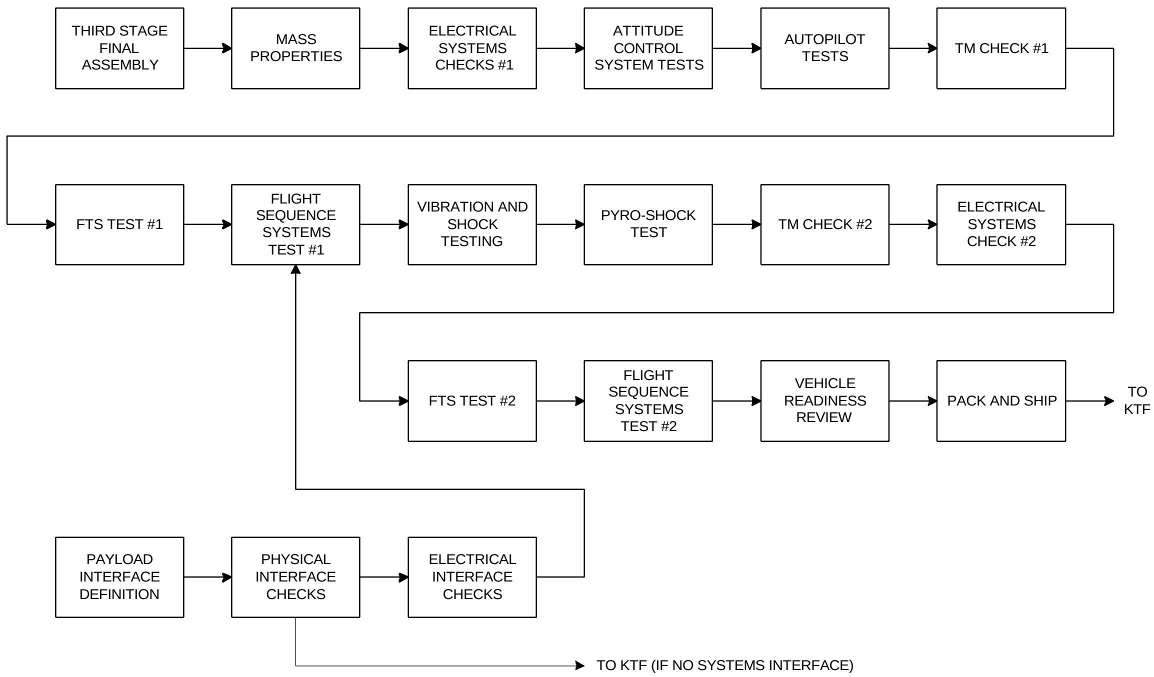

Figure 9.2-1 STARS I Integration and Testing Processing Flow Diagram

cal testing, separate rechargeable nickel cadmium batteries will provide in-ternal power to the TS electrical systems.

4. Attitude Control System Tests - A single axis air bearing will be used to verify satisfactory ACS operation.

5. Autopilot Tests - TS motions are introduced to verify proper FS and TS actuator and SS injector valve commands are generated as a function of outputs from the IMU. All testing is performed using first, second, and third stage motor test sections.

6. TM Checks - The interconnections of TM channels from the signal source through the TM system are verified. These checks are performed both before and after environmental testing.

7. FTS Tests - With the TS electrically mated to an active SS and FS motor test section, a complete electrical checkout of the FTS is performed. Ordnance bridgewire simulators are used to verify the initiation of all FTS ordnance. This test is repeated after environmental testing.

8. Flight Sequence System Tests - While the TS is still electrically mated to the SS and FS motor test sections, a dry run system test will be conducted that simulates the flight sequence. All systems are powered from external power sources utilizing battery simulators through the vehicle umbilicals. Following the satisfactory completion of the flight sequence system test on external power, the test is repeated on internal power using rechargeable batteries. Ordnance bridgewire simulators are

used to verify the initiation of all ordnance. TM data is recorded and reviewed post test to verify subsystem function and timing. This sequence of tests is performed before and after environmental testing. The payload or an electrical simulator are required for these tests to verify the electrical interfaces for any payload ordnance items which are fired by the STARS I vehicle electronics.

9. Vibration and Shock Testing - For each axis, a flight level vibration test and a flight level shock test are conducted with systems operating to verify electrical connections and solder joint integrity.
10. Pyro-Shock Test - With electrical systems operating, a flight level pyro-shock is applied to the TS electronic component section. Payloads may participate in this test.
11. Vehicle Readiness Review (VRR) - This review is held approximately 6 weeks prior to launch. Its purpose is to determine whether the vehicle and payload(s) are ready to be shipped to KTF.
12. Physical Interface Checks - Six to nine months before the flight date, physical interface checks are made using the real payload or a mechanical simulator, to verify the accuracy of the payload mounting hole pattern and cable tie down locations. For multiple payload configurations, the clearance between payloads is checked.

9.2.2 KTF Operations

The functions, presented as a processing flow diagram are shown in Figure 9.2-2. Many of the tests conducted in Albuquerque are repeated at KTF in the MAB using the actual flight motors. These tests include:

- Autopilot Tests
- Attitude Control System Tests
- Flight Sequence System Test
- FTS Tests
- Third Stage Electrical Systems Checks

Once the booster system is determined to be ready for flight, the following additional tasks are completed:

1. Install EEDs and Retro Motors – All booster system EEDs and retro motors are inspected, tested to verify resistance values are within established tolerances, and installed in the vehicle by the ordnance crew. Payload designers are responsible for the installation of payload ordnance, and will abide by the requirements identified in Section 10.3. All EEDs are safed with safing plugs at this time. This activity takes place in the MAB.
2. Final Assembly and Test - All missile sections are mated together. Tests are performed on the booster system to verify all electrical connections are properly

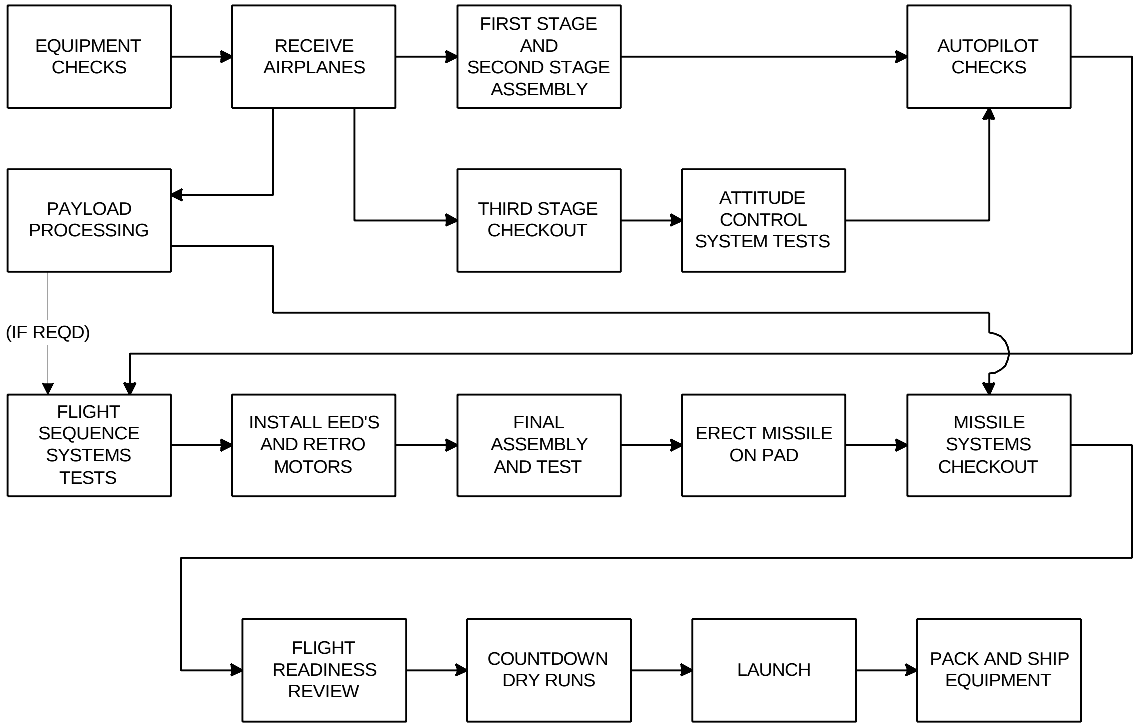

Figure 9.2-2 STARS Field Processing Flow Diagram

made. At the completion of this series of tests the missile is ready to be moved from the MAB to the launch pad.

3. Erect Missile on Pad - The missile is moved to the launch pad, uploaded onto the launch stand, and the MST is rolled into place around the vehicle.
4. Missile Systems Checkout - Final missile preparations are completed. The payload is mated to the missile at this time.
5. Flight Readiness Review (FRR) - The missile and payload processing are reviewed. Any deviation in procedures or anomalies encountered during processing are noted. The readiness of the booster system, the payload(s), and the ranges to proceed with countdown dry runs is verified.
6. Countdown Dry Runs - All aspects of the missile countdown are checked and verified.
7. Launch - Launch operations are discussed in Section 9.3.

9.3 LAUNCH OPERATIONS

STARS launch operations are a series of events beginning with the completion of preliminary missile preparations at T-3 days. The Mission Readiness Test (MRT), a dry run of the countdown with all operation participants, is conducted at T-2 days. The day following the

MRT, the Mission Readiness Review (MRR) is held to determine the readiness of the booster system, the payload(s), and the ranges to support the mission. Final missile and payload preparations also occur on this day. The launch attempts then follow.

9.3.1 Countdowns

Three interrelated and synchronized countdowns are required for a STARS I launch. They are the PMRF, the KTF range, and the STARS missile countdowns. The Launch Readiness Briefing, common to all countdowns, results in a Go/No-Go decision.

9.3.1.1 PMRF Countdown

This is the master countdown for all STARS launch activities. The responsibility for the coordination of all inter-range activities, range safety, and weather monitoring lies with PMRF. Their countdown begins at T-10:30 hours with the launch of a rawinsonde. The wind data measured by the rawinsonde are then used as input to the STARS six-degree-of-freedom trajectory code, and to the program that computes the debris footprints in the event the missile experiences a catastrophic failure. The results of these simulations are used to aid in making the Go/No-Go decision. Additional rawinsondes are launched from PMRF at T-4 and T-2 hours.

Flight Safety activities begin at T-8:00 hours with the checkout of FTS transmitters and sequencer. These activities are coordinated with the KTF countdown and continue throughout the countdown.

The clearance of the Ground Hazard Area (GHA) and Safety Zone begins at T-3 hours, at which time the Missile Accident Emergency Team (MAET) arrives on station. Confimation that the GHA and Safety Zone are clear is given at T-20 minutes. At T-10 minutes, PMRF verifies the final range status. PMRF monitors the flight and other range activities from T=0 to impact.

9.3.1.2 KTF Range Countdown

The KTF range countdown serves as the interface between the PMRF and the STARS missile countdown, as well as coordinating the activities of all KTF range stations. These stations are antenna, booster control, computer, command transmitters, communication control, lead missile engineer for the STARS missile, Strategic Targets Product Manager, receiving and recording, tracking data computer, photography, radar, environmental monitoring, payload, and the off-site station at Maui. The countdown begins at T-8 hours and ends at vehicle impact.

In addition, pilot balloon launches are the responsibility of KTF. After each balloon track is completed, the wind data are transferred to PMRF for use in the debris calculations. The data are also used in the STARS six-degree-of-freedom model to compute the required nozzle deflections (FS) and flow rates (SS) that will be required to compensate for the winds. The balloon launches begin at T-6 hours, and occur continuously until launch. Each run takes approximately 2 hours.

9.3.1.3 STARS Missile Countdown

The STARS missile countdown which begins at T-8 hours is concerned with the missile preparation tasks. These tasks with times are shown in Table 9.3-1.

Table 9.3-1 STARS Missile Countdown Tasks

NUMBER	DESCRIPTION	TIMES
3	Countdown Preparation	(T - 8:00 to T - 6:30)
4	FTS Tests	(T - 6:30 to T - 4:30)
5	FTS Arming	(T - 4:30 to T - 4:00)
6	Missile A&F Arming	(T - 4:00 to T - 3:15)
7	Final Vehicle Preparation	(T - 3:15 to T - 1:50)
8	Booster Fireset Arming	(T - 1:50 to T - 1:25)
9	Countdown Evaluation	(T - 1:25 to T - 1:15)
10	Final Systems Checks	(T - 1:15 to T - 0:30)
11	Terminal Count/Launch	(T - 0:30 to T - 0:00)

The MST retraction occurs during final vehicle preparations. The integration of payload activities into the countdown is determined on an individual mission basis. The STARS missile countdown ends at vehicle impact.

9.3.2 Operation Participants

Operation participants for a STARS launch are shown in Figure 9.3-1. The USASSDC provides overall program guidance with input from the customer. SNL, as the developing and integrated launch services agency, controls the KTF and all missile-related activities.

Range operations are coordinated by PMRF. For STARS missions from KTF, the support ranges include KMR, 30 RANS, DET2 SMC, NAWCWPNS, and other agencies. KMR provides downrange radar tracking, range safety, optics, and telemetry support as requested, and can provide local meteorological conditions near the time of re-entry. 30 RANS provides uprange FPQ-14 metric radar support and a communications network hub through Wheeler Network Communication Control. DET2 SMC is responsible for making the satellite collision avoidance calculations, providing PMRF with the allowable launch windows and the Hawaii Tracking Station located at Kaena Point on Oahu. NAWCWPNS provides Range Safety for STARS, which includes preflight calculations, skyscreen, and range safety officer functions. In addition, NAWCWPNS can provide P-3

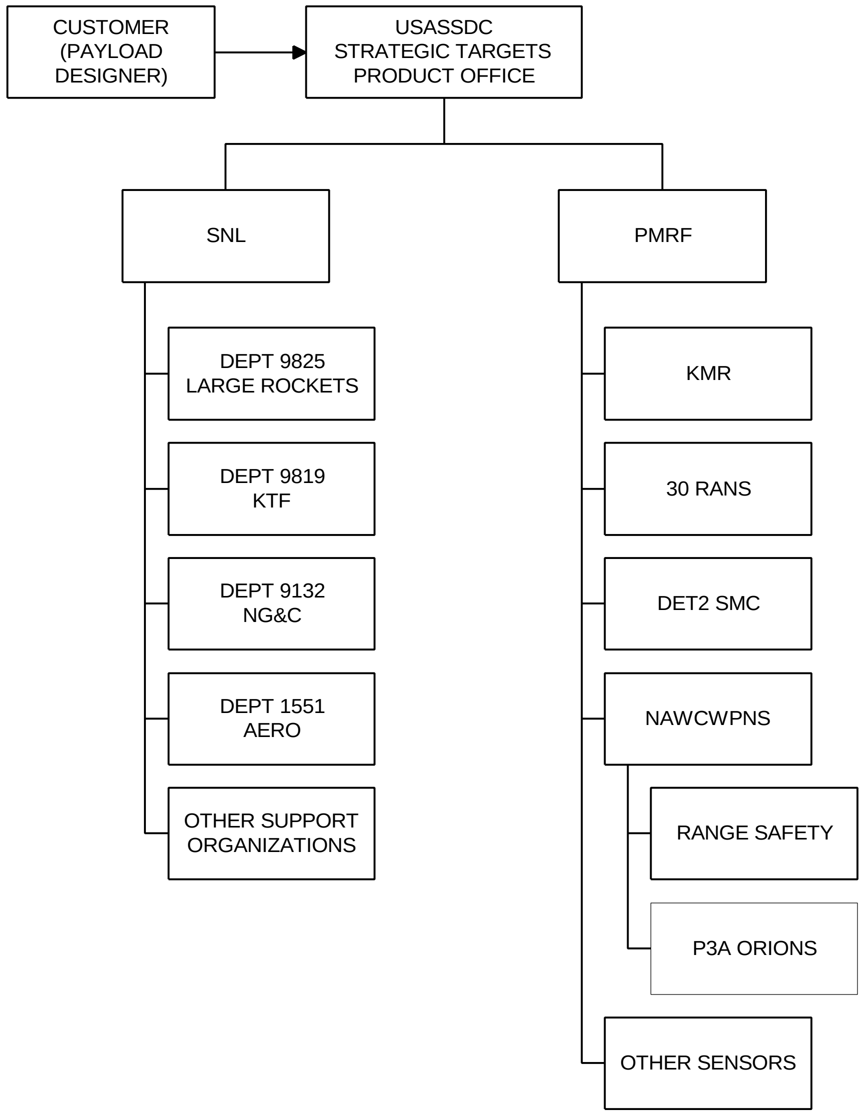

Figure 9.3-1 Launch Operation Participants

aircraft support for telemetry relay and Cast Glance optical tracking data. At the request of the payload designer, PMRF will coordinate other sensor support which includes uprange, downrange, or mobile assets (see Sections 8.6, 8.7, and 8.8).

PMRF, KTF, and KMR have a limited capability to support casual personnel. KTF can support 12 casuals in the LOB during launch. Access to the LOB during launch must be coordinated with SNL. PMRF can support 9 persons in PMRF Range Operations. Due to limited space in T&C Alpha, some personnel may be located in T&C Bravo. Requirements for access to PMRF ROC must be included in the Operations Requirements (OR) document. KMR can support a larger number of casuals. These requirements must also be included in the OR.

10. STARS IMPLEMENTATION REQUIREMENTS

This section provides a description of the overall program management, mission and safety requirements, and mission data associated with a STARS I mission.

10.1 PROGRAM MANAGEMENT

This section defines the overall program management and organizational relationships used for the integration and launch of a payload on the STARS I booster system. The STARS Program, as defined, implements the use of modified Polaris A3 motors and includes both airborne and ground systems in support of a payload launch. The STARS Program is directed by the BMDO. The Strategic Targets Product Manager is assigned to the USASSDC, Huntsville, AL.

10.1.1 Program Organization

The Strategic Targets Product Office of USASSDC has been assigned the overall management responsibility for STARS. The Strategic Targets Product Manager is the system program management focal point for projects utilizing this booster system. Teledyne Brown Engineering is responsible for Systems Engineering and Technical Assistance (SE/TA) efforts performed for the STARS Program. The Sandia National Laboratories is the USASSDC designated launch agency.

Ogden Air Logistics Center (OO-ALC) is responsible for various logistics activities supporting the STARS first and second stage motors. These activities include monitoring the motor storage environments, movement of the motors between the storage sites and the motor manufacturer for refurbishment, and movement of the motors to Hill Air Force Base (HAFB) for final assembly and check out before shipment to KTF. OO-ALC also schedules and coordinates the AMC SAAM flights for the product office. The retro motors used on the STARS I booster system are provided by OO-ALC.

Communications concerning range requirements should be coordinated with PMRF. This management concept is shown in Figure 10.1-1.

10.1.2 Program Control

System program management control is accomplished through Program Manager's Reviews and Range Planning Meetings (PMR/RPM), and a series of mission documents which provide the necessary visibility to all agencies for the integration of a payload with the STARS I booster system.

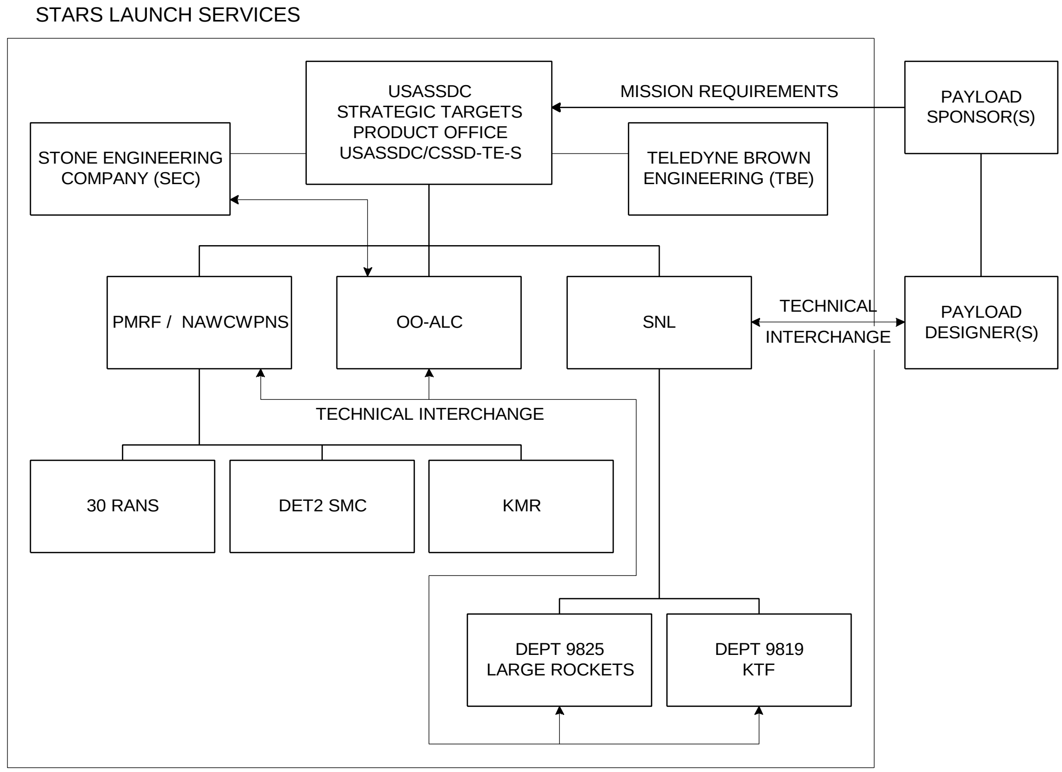

Figure 10.1-1 STARS Management Concept

10.1.3 Program Scheduling

The Strategic Targets Product Office is responsible for developing, publishing, and distributing the overall program schedule to support the customer's desired launch date. A typical STARS program timeline from conception to launch is shown in Figure 10.1-2.

SNL is responsible for developing mission specific schedules in support of the program schedule and through the product office, for informing the payload designer when specific items are required at SNL for integration, testing, and shipment.

PMRF is responsible for scheduling all range assets required to support the mission.

10.2 MISSION REQUIREMENTS

This section summarizes the documentation that must be prepared before the mission can be conducted.

STARS Typical Mission Timeline

	Months Prior to Launch												
Activities	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Payload Concept Letter (T-24 Months) (If Required)													
Preliminary Trajectories Available (T-23 Months)													
Payload Kickoff Meeting (T-18 Months)													
Payload Telemetry Requirements (T-18 Months)													
PAYLOADERS DOCUMENTATION													
OR Planning	◇												
Draft #1		◇	◇										
Draft #1 Review			◇	◇									
Draft #2						◇	◇						
Draft #2 Review							◇	◇					
Final OR Published									◇	◇			
PMRF Range OD Published											◇	◇	
STARS Vehicle Peculiar Supplement (If Required)											◇	◇	
Range Planning Meetings	◇			◇			◇			◇			
Payload Modal Test Results				◇									
Trajectories Available				◇									
Missile Motor (FS & SS) Refurbishment							◇	—	◇				
GTM Exercise (If Required)									◇				
Missile Motor Build-up @ Hill AFB										◇	◇		
Final Trajectories Published (T-90 Days)										◇			
SAAM Flight Requests (T-60 Days)											◇		
Vehicle Readiness Review (T-45 Days)												◇	
CIS Notification Process (T-40/30/20/13 Days)												◇◇◇	◇
Record of Environmental Consideration (T-30 Days)												◇	
Message to JPASO, Confirm Launch (T-30 Days)												◇	
Payload/Booster Shipment (T-30 Days)												◇	
PMRF Confirm Range Safety Parameters (T-30 Days)												◇	
NAWC Range Safety Approval (T-30 Days)												◇	
Final Countdown Checklist (T-21 Days)												◇	
Notify DLNR/DOT/Kekaha of Launch (T-7 Days)													◇
Flight Readiness Review (T-7 Days)													◇
PMRF Notify NORAD (T-5 Days)													◇
PMRF Publish NOTAM/NOTMAR (T-3 Days)													◇
KMR Publish NOTAM/NOTMAR (T-2 Days)													◇
Mission Readiness Test (T-2 Days)													◇
Mission Readiness Review (T-1 Day)													◇
Launch (T=0)													◇

Figure 10.1-2 STARS I Typical Mission Timeline

10.2.1 Payload Requirements

The payload designer is responsible for providing the following information to SNL:

- Mechanical and electrical simulators as defined in Section 4.4, including functional electrical schematics.
- Test reports showing payload survival of dynamic environments as defined in Section 5.4.
- Payload modal characteristics as defined in Section 5.5, including mass properties, frequencies, and mode shapes.
- Schedule of payload field processing requirements, including any payload specific countdown requirements.
- Payload Field Processing Procedures.
- A list of all hazardous payload components.

10.2.2 Mission Planning

The information described in the following subsections must be provided to aid in planning the mission.

10.2.2.1 Mission Concept Letter

A minimum of 24 months prior to launch, the payload designer should provide the Strategic Targets Product Office with a mission concept letter containing the following information:

- A brief description describing the purpose of the mission.
- The desired re-entry conditions and pierce point.
- The estimated weight, size, shape, center of gravity, and ballistic coefficient of the payload.

If a specific target/complex is requested, then a target system requirements document also must be provided. The contents of this document are defined in the BMDO Consolidated Targets Program Master Plan12.

10.2.2.2 Mission Requirements Document (MRD)

The MRD identifies all mission requirements and specifies (either directly or by reference to other specific documents) all parameters which may impact more than one agency. The objective of the MRD is to document and verify concurrence in the following items:

- The flight configuration for the launch vehicle and the payload.
- All requirements levied on the launch vehicle system by those organizations responsible for the payloads.

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[12] *BMDO Consolidated Targets Program Master Plan*, December 1993.

- All payload data which is required for evaluation to ensure total compatibility with the launch vehicle system.
- Prelaunch and in-flight payload environments.
- Ground rules governing restrictions imposed on payloads to ensure launch vehicle compatibility.
- A description of the interfaces and a summary of the planned integrated tests.
- Range requirements.

The MRD is prepared and released by USASSDC.

10.2.2.3 Detail Flight Test Plan (DFTP)

The DFTP is developed by the payload designer. It contains a detailed description of the total mission, including hardware, data requirements, and planning and operations information. The DFTP specifies the types, quantity, and format for data required from range sensors for prelaunch and launch operations. It aids in establishing the payload Go/No-Go criteria for launch. The DFTP is a historical document to the extent of providing a record of the configuration flown, of objectives and requirements of the test, and of the relationships of the test to the STARS I booster system and other flight tests in the payload program.

10.2.2.4 Go/No-Go Launch Decision Criteria

USASSDC will develop Go/No-Go launch decision criteria with inputs from all participants. These criteria will be coordinated during planning meetings and published at least 60 days prior to the launch.

10.2.3 Range Planning

PMRF utilizes the Universal Documentation System (UDS) to provide range support in a timely manner in accordance with the range user requirements. The system starts with early planning data for the long-lead time requirements. It culminates with a set of detailed requirements that are agreed to by PMRF and the range user to support the mission. A complete description of the UDS, including sample forms and detailed instructions for their preparation, are contained in *Range Commanders Council-Documentation Group (RCC-DG) documents 501, Volumes I, II, and III*[13].

For the STARS program, the STARS booster Program Introduction (PI) was prepared by USASSDC. The response to the PI, the Statement of Capability (SC), was then prepared by PMRF. The Program Requirements Document (PRD) expands on the requirements of the PI and SC, and was written by USASSDC. PMRF in turn has responded with the Program Support Plan (PSP), which is a page-by-page response to the PRD. All four of

[13] *RCC-DG document 501, Volumes I, II, and III.*

these documents are in place for the STARS I program, and are available for use by the payload designer(s).

The payload designer will be provided with copies of the PI, SC, PRD, and PSP. The payload designer should use these documents as guidelines in preparing their inputs for the OR.

10.2.3.1 Operations Requirements (OR) Document

The OR is a mission-oriented document that describes in detail the requirements for each mission. The OR is published 90 days prior to launch or first use. USASSDC issues the OR. Preparation of the OR is dependent on the experiment/test configuration specifics as contained in the DFTP (see Section 10.2.2.3) provided by the payload designer. PMRF replies to the OR with an Operations Directive (OD), which assigns the resources to support the requirements (Section 10.2.3.4). Inputs are required from the payload designer at least 30 days prior to the scheduled publish date of each OR. No new requirements can be introduced in the OR unless previously approved in the PRD.

10.2.3.2 Operations Requirements Extract (ORE)

The ORE applies to the OR at the mission/test level. It relates to the lead support agency concept where the lead agency must levy derivative requirements on other agencies. In general, the basic requirements will be extracted from the user’s original OR and expanded upon by the lead agency. It is also used by the user to make few (in number) and expedite changes to the OR.

10.2.3.3 Vehicle Peculiar Supplements (VPS)

The OR VPS, prepared by USASSDC, and the corresponding OD VPS, prepared by PMRF, only give information that is unique to a single launch operation. The OR VPS will be prepared based on the information contained in the DFTP released by the payload designer for each launch.

10.2.3.4 Operations Directive (OD)

The OD is the final document in the UDS series. It is the official range directive released by PMRF which mobilizes and assigns the resources necessary to support the range user's requirements identified in the OR.

10.2.3.5 Program Sensor Plan

The program sensor plan is developed by the ranges to meet the payload designers requirements for sensor coverage. The plan details which assets will be assigned to specific objects during a given time period during the mission. Test plans for support from mobile sensors will be provided during the final range planning meeting for the mission.

10.2.4 Review Meetings

Normally there are five types of meetings called by the STARS program in which the payload designer is required to participate. These are:

1. Range Planning Meetings (RPM) are used to coordinate the range requirements for the specific mission. These are scheduled to occur about every nine months.
2. The Vehicle Readiness Review (VRR) is held approximately 6 weeks prior to the launch date. It is normally held at SNL. The VRR is used to determine whether the vehicle and payload(s) are ready to be shipped to KTF.
3. The Flight Readiness Review (FRR) is normally held at KTF approximately 1 week before the scheduled launch date. The purpose of this meeting is to review the missile and payload processing, and range readiness with the Strategic Targets Product Office. Any deviation in procedures or anomalies noted during the system buildup are discussed at this time.
4. The Mission Readiness Review (MRR) is normally held after the Mission Readiness Test (MRT) at PMRF. The MRR is used to review the readiness of the STARS booster system, payload, and ranges to support the mission.
5. The Post-Mission Debriefing is held the day after the mission to review all activities associated with the countdown, launch, and flight.

10.3 ENVIRONMENTAL AND SAFETY REQUIREMENTS

10.3.1 Environmental Requirements

The Strategic Targets Product Office has completed the *Final STARS Environmental Impact Statement*[14] (EIS) for the STARS program as well as the *Final EIS with Restrictive Easement*[15] for PMRF. Each payload designer is required to read and certify to the Product Office that they are in compliance with the *Final STARS EIS*. The Product Office will request a Record of Environmental Consideration (REC) from the Environmental Office, supplying the information provided by the payload designer. Should the payload environmental hazards be trivial, the Environmental Office may waive the REC requirement.

10.3.2 Ground Safety

Payload designers will abide by the KTF Standard Operating Procedure16 (SOP), the STARS SOP17, and the STARS EIS. Special training and certification may be required to operate equipment at the KTF. Payload Field Processing Procedures must be submitted to

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[14] *Final STARS EIS*, US Army, Kauai, Hawaii, May 1993.
[15] *Final EIS with Restrictive Easement*, US Navy, Kauai, Hawaii, October 1993.
[16] *Operations at Kauai Test Facility*, SNL, SP472378, December 2, 1992.
[17] *Handling, Assembly, Test and Launch Operation for STARS I*, SNL, SP472244, June 22, 1992.

SNL for approval of all hazardous operations to be conducted at the KTF. These operations include, but are not limited to, explosives, chemicals, radiation, and pressure sources. The procedures should include all applicable Material Safety Data Sheets (MSDS) and exact quantities of hazardous sources. They also should include plans and procedures for assembly, transportation, and testing. All safety hazards and their mitigation measures must be addressed. No provisions exist either at KTF or PMRF for the long term storage of explosives or chemicals. All hazardous waste must be identified and provisions shall be made by the payload designer to transport all unused hazardous materials and all hazardous waste that cannot be handled by PMRF, back to the CONUS. The generation of mixed waste is not allowed.

The payload designer must abide by the safety criteria as outlined in paragraph 2.10.2 of the *PMRF Range User's Handbook* and with the *Final STARS EIS*.

10.3.3 Flight Safety

Payload designers are required to provide information, such as payload demise, to aid in predicting debris patterns and hazardous effects in the event of a payload or missile breakup. If the payload is maneuverable or self-propelled, a complete analysis of the maximum attainable range and attitude of the payload will be required in order to complete a comprehensive flight safety data package. A flight safety data package will be generated for each mission. It should be noted that the ranges may require an FTS on maneuvering payloads.

10.4 SECURITY

10.4.1 Personnel

Personnel planning to visit or work at KTF must submit the proper visit request information as listed below. To limit the possibility of injury, personnel are only allowed access to areas where they are needed.

10.4.1.1 Unclassified Operations

SNL/KTF is a tenant on the PMRF. For PMRF entry, a "Request for Visit or Access Approval" (USDOE Form F5631.20 or equivalent) will be mailed, messaged, or faxed with hard copy mailed to:

COMMANDING OFFICER
PACIFIC MISSILE RANGE FACILITY
CODE 7001-3
PO BOX 128
KEKAHA, KAUAI, HAWAII 96752-0128
PMRF FAX (808) 335-4476, CONFIRMATION (808) 335-4207

The "Request" may also be transmitted via US Joint Message Centers to the following address:

From: (Activity requesting access)

To: RUHHAIA/PACMISRANFAC HAWAREA,
CODE 01-3/BARKING SANDS, HI.

Info: RUHHAIA/SANDIA CORP., BARKING SANDS, HI.

A duplicate copy of this request should also be mailed or faxed to:

SANDIA NATIONAL LABORATORIES
KAUAI TEST FACILITY
PO BOX 308
WAIMEA, KAUAI, HAWAII 96796-0308
SNL/KTF FAX (808) 337-9013, CONFIRMATION (808) 335-5611

10.4.1.2 Classified Operations

In addition to the requirements for unclassified visits specified in Section 10.4.1.1, a "Request for Visit" must also be mailed, or faxed with a hard copy mailed to:

SANDIA NATIONAL LABORATORIES
PERSONNEL SECURITY/VISITOR CONTROL DIV. 7437-1/MS 0171
PO BOX 5800
ALBUQUERQUE, NM 87185-0171
SNL, FAX (505) 844-4263, CONFIRMATION (505) 845-8140

10.4.1.3 Visit Miscellaneous

A one-day unclassified visit to SNL/KTF, does not require a "Request for Visit". The KTF office staff can authorize the visit. For point of contact (POC):

a. To visit SNL/KTF only, mark "Facility Manager, SNL/KTF". Contact SNL for the current facility manager's name.

b. To visit PMRF operations in addition to SNL/KTF, mark "Strategic Targets Program Manager - PMRF and Facility Manager - SNL/KTF"

Upon arrival at PMRF, visitors should report to the main gate visitor's center for processing and badging. If visiting KTF, they must also report to the KTF office.

10.4.2 Hardware

The classification and control measures for the payload(s) needs to be identified early in the planning stages of the mission. Provisions must be made prior to shipment for proper transportation, handling, and storage of all classified materials. KTF has the provision to accommodate classified hardware and documents as noted in Sections 7.1.1 through 7.1.4. PMRF has the capability to handle documents with a higher classification than Secret.

10.5 MISSION DATA

10.5.1 Pre-Mission

SNL will provide final trajectory data 90 days prior to launch. All data obtained during qualification testing, including calibrations, are available to the payload designer if requested. All data generated prior to shipment will be presented at the VRR and included in the Missile Build Book. This will be available for review during the FRR. Final assembly and checkout procedures, plus data generated during the MRT will be reviewed at the MRR.

10.5.2 Flight Data

Payload designers who utilize the missile TM will be provided with a magnetic TM tape approximately 1 day after launch by SNL. All other sensor and performance data will be available as requested in the mission specific OR. The data products will be as previously coordinated during range planning meetings.

10.5.3 Reports

USASSDC, with the assistance of PMRF, SNL and the payload designers, will prepare a quick-look report. This report will contain an uprange quick-look data analysis of the predicted and actual event times, and data pertaining to the launch vehicle and payload performance. Each agency will submit data as required within the time specified by USASSDC. The report will be sent to the recipients specified.

Approximately 1 day after launch, a meeting may be held to summarize the launch and flight performance results based on available data. The meeting will be chaired by USASSDC, with presentations given by members of the launch team and other range representatives.

Following the preparation of the quick-look report, data will continue to be analyzed as it becomes available. The mission Final Report will cover missile flight performance. The payload performance report is the responsibility of the payload designer.

APPENDIX A

ABBREVIATIONS AND ACRONYMS

APPENDIX A

ABBREVIATIONS AND ACRONYMS

A	Amp
A&F	Arm and Fire
A/D	Analog to Digital
AB	Assembly Building
ACS	Attitude Control System
AEB	Auxiliary Equipment Building
AGC	Automatic Gain Control
AMC	Air Mobility Command
AMOS	Air Force Maui Optical Station
APIS	Automatic Precision IFF Surveillance System
AUTODIN	Automatic Digital Network
AWG	American Wire Gage
BL	BiLevel
BMDO	Ballistic Missile Defense Organization
BMIC	Battle Management Interoperability Center
BP	BiPolar
CBW	Constant Bandwidth
CDX	Countermeasures Demonstration Experiment
CFM	Cubic Feet per Minute
CG	Center of Gravity
CIS	Confederation of Independent States
CMOS	Complimentary Metal Oxide Semiconductor
CMS	Component Mode Synthesis
CPIA	Chemical Propellant Information Agency
cw	Continuous Wave
D/A	Digital to Analog
dB	Decibel
DAC	Digital to Analog Converter
DC	Direct Current
DCMC	Defense Contract Management Command
DCS	Defense Communication Systems
DCTN	Defense Commercial Telecommunications Network
DET2 SMC	Detachment 2 Space and Missile Systems Center
DFTP	Detail Flight Test Plan
DLNR	Department of Land and Natural Resources (State of Hawaii)
DoD	Department of Defense
DOE	Department of Energy

DOT	Department of Transportation
DR	Down Rated
E-O	Electro-Optical
ea	Each
EED	Electro-Explosive Device
EIS	Environmental Impact Statement
EMI	Electromagnetic Interference
ES	Equipment Section
FEM	Finite Element Model
FLSC	Flexible Linear Shaped Charge
FM	Frequency Modulation
FS	First Stage
ft	Feet
FRR	Flight Readiness Review
FTS	Flight Termination System
G/T	Gain/Temperature
GBL	Government Bill of Lading
GEODSS	Ground-based Electro-Optical Deep Space Surveillance System
GHA	Ground Hazard Area
GHz	Gigahertz
GPS	Global Positioning System
GPSEM	GPS Embedded Module
GTM	Ground Test Missile
HAFB	Hill Air Force Base
HAP	Hydraulic Actuator Package
HGG	Hot Gas Generator
HH	Hook Height
HIANG	Hawaii Air National Guard
HL	HiLevel
HPDP	Hydraulic Power Distribution Package
HTPB	Hydroxyl-Terminated Polybutadiene
HTS	Hawaii Tracking Station
Hz	Hertz
IC	Integrated Circuit
ICD	Interface Control Document/Drawing
IF	Intermediate Frequency
IFF	Identification Friend or Foe
IFLOTS	Intermediate Focal Length Optical Tracker
IIP	Instantaneous Impact Point
IMU	Inertial Measurement Unit
in	Inch

INS	Inertial Navigation System
IPS	Inches per Second
IRIG	Inter-Range Instrumentation Group
IS	Interstage Section
JPASO	Joint Pacific Area Scheduling Office
K	Kelvin
Kft	Kilofeet
Khz	KiloHertz
km	Kilometer
KMR	Kwajalein Missile Range
KTF	Kauai Test Facility
lb	Pounds
lb/ft2	Pounds per Foot Squared
lbm	Pounds (Mass)
LHC	Left Hand Circular
LL	LoLevel
LLLTV	Low Light Level TV
LOB	Launch Operations Building
LSB	Least Significant Bit
LWIR	Long Wavelength Infrared
LWIS	Light Weight Instrumentation System
MAB	Missile Assembly Building
MAET	Missile Accident Emergency Team
MAPS	Modular Azimuth Positioning System
MDF	Mild Detonating Fuse
MFSO	Missile Flight Safety Officer
Mhz	MegaHertz
MILSTAMP	Military Standard Transportation and Movement Procedures
MIPIR	Missile Precision Instrumentation Radar
MMAA	Maxi-Max Absolute Acceleration
MOTIF	Maui Optical Tracking and Identification Facility
MRD	Mission Requirements Document
MRR	Mission Readiness Review
MRT	Mission Readiness Test
MS	Missile Station
MSC	Military Sealift Command
MSDS	Material Safety Data Sheet
MSSS	Maui Space Surveillance Site
MST	Missile Service Tower
MTMC	Military Traffic Management Command
mV	Millivolts
NAWCWPNS	Naval Air Warfare Center Weapons Division
NEW	Net Explosive Weight
NF	Nose Fairing
NG&C	Navigation, Guidance and Control

nm	Nautical Mile
NORAD	North American Air Defense Command
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NRZ-L	Non-Return-to-Zero Level
NTDS	Navy Tactical Data System
NWAC	Naval Warfare Assessment Center
O&M	Operations and Maintenance
OC	Operations Conductor
OD	Operations Directive
OO-ALC	Ogden Air Logistics Center (USAF)
OR	Operations Requirements
ORE	Operations Requirements Extract
PAM	Pulse Amplitude Modulation
PBW	Proportional Bandwidth
PCM	Pulse Code Modulation
PI	Program Introduction
PMR	Program Manager's Review
PMRF	Pacific Missile Range Facility
POC	Point of Contact
PRD	Program Requirements Document
PSD	Power Spectral Density
psi	Pounds per Square Inch
psia	Pounds per Square Inch Absolute
R&D	Research and Development
RAM	Random Access Memory
RCC	Range Contractor Controller
RCC-DG	Range Commanders Council - Documentation Group
RCS	Range Communication Systems
REC	Record of Environmental Consideration
RF	Radio Frequency
RFCO	Range Facility Control Office
RHC	Right Hand Circular
RLG	Ring Laser Gyro
rms	Root Mean Square
RMST	Rocket Motor Staging Area
ROC	Range Operations Center
RPM	Range Planning Meeting
RSS	Root Sum Squared
RTCC	Real Time Computer Center
RV	Reentry Vehicle
SAAM	Special Assignment Airlift Mission
SANDAC	Sandia Digital Airborne Computer
SC	Statement of Capability
SCN	Satellite Control Network

SDI	Scientific Devices, Incorporated
SE	Systems Engineering
SE	Support Equipment
SEC	Stone Engineering Company
SFID	Subframe Identifier
SGLS	Space Ground Link Subsystem
SKU	Guidance parameter that controls loft of trajectory
SNL	Sandia National Laboratories
SOP	Standard Operating Procedures
SPL	Sound Pressure Level
SPS	Samples per Second
SRS	Shock Response Spectrum
SS	Second Stage
STARS	Strategic Target System
T&C	Tracking and Control
TA	Technical Assistance
TALO	Time After Liftoff
TBE	Teledyne Brown Engineering
TI	Texas Instruments
TM	Telemetry
TMD	Theater Missile Defense
TS	Third Stage
TSAP	Trajectory Simulation and Analysis Program
TT&C	Telemetry, Tracking, and Commanding
TVC	Thrust Vector Control
TWS	Track While Scan
UDS	Universal Documentation System
UHF	Ultra High Frequency
USAF	US Air Force
USAKA	US Army Kwajalein Atoll
USASSDC	US Army Space and Strategic Defense Command
UTC/CSD	United Technologies Corporation, Chemical Systems Division
V	Volt
VCO	Voltage Controlled Oscillator
VGP	Vehicle Ground Point
VPS	Vehicle Peculiar Supplement
VRR	Vehicle Readiness Review
VTACS	Video Tactical Analysis and Critique System
W	Watt
WGS	World Geodetic System
WNCC	Wheeler Network Communication Center
30 RANS	30th Range Squadron

APPENDIX B

CMS WRITE-UP

APPENDIX B

CMS WRITE-UP

Partition the system into boundary d.o.f. (B) and interior d.o.f. (I)

$$\begin{bmatrix} m_{II} & m_{IB} \\ m_{BI} & m_{BB} \end{bmatrix} \begin{Bmatrix} \ddot{u}_I \\ \ddot{u}_B \end{Bmatrix} + \begin{bmatrix} k_{II} & k_{IB} \\ k_{BI} & k_{BB} \end{bmatrix} \begin{Bmatrix} u_I \\ u_B \end{Bmatrix} = \begin{Bmatrix} f_I \\ f_B \end{Bmatrix} \tag{1}$$

where m_{II}, k_{II}, m_{BB} & k_{BB}, are symmetric and $m_{IB} = m_{BI}^T$ & $k_{IB} = k_{BI}^T$. The boundary d.o.f. will be retained as physical coordinates, while the interior d.o.f. will be eliminated in favor of generalized (modal) coordinates.

Consider a transformation using the generalized coordinates $\{p\}$

$$\{u\} = \begin{Bmatrix} u_I \\ u_B \end{Bmatrix} = [\Psi]\,\{p\} = \begin{bmatrix} y_1 & y_2 & . & . & . & y_N \end{bmatrix} \{p\} \tag{2}$$

where $\{p\}$ contains a combination of coordinates corresponding to each component mode, $\{y_i\}$. The Craig-Bampton method uses two types of component modes:

$[y_c]$ = constraint modes

$[y_e]$ = elastic fixed-boundary modes

Hence, equation (2) may be partitioned

$$\{u\} = \begin{Bmatrix} u_I \\ u_B \end{Bmatrix} = \begin{bmatrix} [y_e] & [y_c] \end{bmatrix} \begin{Bmatrix} p_e \\ p_c \end{Bmatrix} = \begin{bmatrix} [y_e] & [y_c] \end{bmatrix} \begin{Bmatrix} p_e \\ u_B \end{Bmatrix} = [\Psi]\,\{p\} \tag{3}$$

<u>Constraint modes</u> are defined by imposing a (static) unit displacement on each boundary d.o.f. in turn, while holding the remaining boundary d.o.f. fixed:

$$[y_c] = \begin{bmatrix} \Psi_{Ic} \\ I_{cc} \end{bmatrix} \tag{4}$$

where I_{cc} is an identity matrix with the same number of rows as $\{u_B\}$ (see below).

The upper partition of equation (1) is (static case)

$$[k_{II}]\,\{u_I\} + [k_{IB}]\,\{u_B\} = \{0\}$$

whence

$$\{u_I\} = -[k_{II}]^{-1}[k_{IB}]\{u_B\} \tag{5}$$

Applying a sequence of unit displacements at the boundary d.o.f., $\{u_B\}$ is replaced by $[I_{cc}]$, and equation (5) yields the upper partition of the constraint mode matrix

$$[\Psi_{Ic}] = -[k_{II}]^{-1}[k_{IB}][I_{cc}] \tag{6}$$

The constraint mode matrix follows as

$$[y_c] = \begin{bmatrix} \Psi_{Ic} \\ I_{cc} \end{bmatrix} = \begin{bmatrix} -[k_{II}]^{-1}[k_{IB}] \\ I_{cc} \end{bmatrix} \tag{7}$$

The transformation defined by equation (7) is simply the Guyan reduction, or static condensation, to the boundary d.o.f. The constraint modes are simply columns of this transformation matrix.

Elastic modes are the free vibration modes of the system with all boundary d.o.f. fixed. In terms of equation (1), the pertinent eigensolution is

$$\left(-w_e^2[m_{II}] + [k_{II}]\right)\{\Psi_{Ie}\} = \{0\} \tag{8}$$

Since the boundary d.o.f. are fixed, the modal matrix is

$$[y_e] = \begin{bmatrix} \Psi_{Ie} \\ 0 \end{bmatrix} \tag{9}$$

where $\Psi_{Ie}^T m_{II} \Psi_{Ie} = I_{ee}$ and $\Psi_{Ie}^T k_{II} \Psi_{Ie} = [w_e^2]$ (diagonal).

Combining the elastic modes [equation (9)] with the constraint modes [equation (7)], the C-B transformation of coordinates is

$$[\Psi] = \left[\, [y_e] \quad [y_c] \,\right] = \begin{bmatrix} \Psi_{Ie} & \Psi_{Ic} \\ 0 & I_{cc} \end{bmatrix} \tag{10}$$

Whence, using equation (2) or (3)

$$\{u\} = \begin{Bmatrix} u_I \\ u_B \end{Bmatrix} = \begin{bmatrix} \Psi_{Ie} & \Psi_{Ic} \\ 0 & I_{cc} \end{bmatrix} \begin{Bmatrix} p_e \\ p_c \end{Bmatrix} = [\Psi]\{p\} \tag{11}$$

The reduced mass and stiffness matrices, in the new coordinates $\{p\}$, are obtained as

$$m^{CB} = [\Psi]^T[m][\Psi] \quad ; \quad k^{CB} = [\Psi]^T[k][\Psi] \tag{12}$$

Carrying out these operations and partitioning, the reduced system becomes

$$m^{CB} = \begin{bmatrix} m_{ee} & m_{ec} \\ m_{ce} & m_{cc} \end{bmatrix} \; ; \quad k^{CB} = \begin{bmatrix} k_{ee} & k_{ec} \\ k_{ce} & k_{cc} \end{bmatrix} \tag{13}$$

where

$$\begin{aligned}
\left[m_{ee}\right] &= \left[I_{ee}\right] \\
\left[m_{ec}\right] &= \left[\Psi_{Ie}^{T}\right]\left(\left[m_{II}\right]\left[\Psi_{Ic}\right]+\left[m_{IB}\right]\right) \\
\left[m_{ce}\right] &= \left[m_{ec}^{T}\right] \\
\left[m_{cc}\right] &= \left[\Psi_{Ic}^{T}\right]\left(\left[m_{II}\right]\left[\Psi_{Ic}\right]+\left[m_{IB}\right]\right)+\left[m_{IB}\right]\left[\Psi_{Ic}\right]+\left[m_{BB}\right]
\end{aligned} \tag{14}$$

and

$$\begin{aligned}
\left[k_{e}\right] &= \left[w_{e}^{2}\right] \text{ (diagonal)} \\
\left[k_{ec}\right] &= [0] \\
\left[k_{ce}\right] &= [0] \\
\left[k_{cc}\right] &= \left[k_{BB}\right]-\left[k_{BI}\right]\left[k_{II}\right]^{-1}\left[k_{IB}\right]=\left[k_{BB}\right]+\left[k_{BI}\right]\left[\Psi_{Ic}\right]
\end{aligned} \tag{15}$$

Subscript Summary

I = Interior (non-boundary) d.o.f. — B = Boundary d.o.f.

c = Constraint mode (physical d.o.f.) — e = Elastic mode (generalized d.o.f.)

Procedure Summary

1. Form constraint modes, equation (7)
2. Solve fixed boundary eigensolution, equation (8)
3. Form reduced mass and stiffness matrices, equations (13, 14 & 15)
4. Report $[y_{c}]$, $[y_{e}]$, $[m^{CB}]$, and $[k^{CB}]$
5. Report, for reference, terms (matrix blocks) in equation (1) for the system

APPENDIX C

TELEMETRY SUMMARY

APPENDIX C

TELEMETRY SUMMARY

The STARS I telemetry stream provides a wealth of information that could be useful to the payloader in determining the payload environment, either prior to the release from the third stage, or during a critical part of the mission where the vehicle state must be known in real time. The complete list of variables is exhaustive; and is not included in this appendix. However, the following summary is provided to give the experimenter an idea of the types of information available. Most of the parameters shown are available at a 16, 64, and 256 Hz rate.

1. TALO: Time after Liftoff at 16, 64, and 256 Hz.
2. Geographic Position: Altitude, Latitude, and Longitude.
3. Geographic Velocity: North, East, and Down Components.
4. GPS Derived State: Position and Velocity from GPS Measurements.
5. Accelerations: Longitudinal and Lateral (Pitch and Yaw).
6. Euler Angles: Pitch, Yaw, and Roll.
7. Body Rates: Pitch, Yaw, and Roll.
8. Discretes: Turn on, Separate Fiducials.

In addition, the flexibility offered by the SANDAC allows mission specific functions to be programmed and output into the telemetry stream. Because the inclusion of any mission specific parameters will most likely require changes in the overall STARS I telemetry stream, any special data requirements should be submitted to SNL 12 months before the scheduled flight date.

APPENDIX D

REFERENCES

APPENDIX D

REFERENCES

The following listing identifiesthe technical documents referenced in the main text of this handbook.

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